ERIC Document Resume | See Instruction Sheet | DATE OF RESUME | DATE RECEIVED

A. PUBLICATION DATA

1. ERIC NUMBER ED001189

2. ORIGINATOR CONTROL NO(S). N.A.

3. IDENTIFICATION NO. N.A.

4. AUTHOR(S): Taylor, Calvin W., Cooley, Gary M., and Nielson, Edwin C.

5. TITLE OF DOCUMENT ABSTRACTED:
Identifying High School Students with Characteristics Needed in Research Work

6. PUBLICATION TITLE: N.A.

7. EDITOR(S): N.A.

8. PLACE OF ORIGIN
ORG. Dept. of Psychology,
ST. University of Utah,
CITY, STATE Salt Lake City, Utah
TELE. EXT.
INST/LOC CODE

9. PUBLISHER OR SOURCE Department of Psychology
University of Utah
Salt Lake City, Utah

10. VOL. N.A.
11. PAGES N.A.
12. MO./YR. April '63
13. TOTAL PP. 62

DO NOT WRITE IN SPACE BELOW

MICROFILM COPY AVAILABLE
YES ☒ NO ☐

COPYRIGHT GRANTED
YES ☐ NO ☒

COPYRIGHT RELEASE FILED
YES ☐ NO ☐

TYPE OF REPORT
PROPOSAL ☐
IN-PROGRESS ☐
FINAL ☒
FOLLOW-UP ☐

OTHER ERIC REFERENCES:

ERIC SATELLITE CODE

B. INDEXING DATA

14. SUBJECT AREA

15. TYPE OF ENDEAVOR Report

16. INDEXING TERMS (6-12)	Laboratory Exercises	Sciences	Self Description
Summer Science Programs	Academic Type	Aptitude Tests	Research
National Science Foundation	Research-Participation Type	Achievement Scale	Secondary Ed.
High School Students	Subject Matter	Biographical Information	
	Psychological Processes	Student Characteristics	

17. ABSTRACT (MAX. 250 WORDS)

A study was conducted of nine National Science Foundation summer science programs for high school students during the summer of 1961. The types of summer programs studied were the academic type and the research-participation type. In the academic-type programs, the students received an advanced treatment of subject matter and laboratory exercises, generally in the biological or physical sciences. In the research-participation type the students worked on research problems of their own choice, or they joined ongoing projects as junior members of a professional research team.

Through evaluation and use of the grade point average and intelligence quotient, aptitude tests, satisfactory achievement scale, biographical information survey, self description, National Merit Scholarship Corporation form, and numerous single correlations and potential combinations, certain conclusions were made.

These results show that children with outstanding research ability can be known for observation and scoring at an early age. Also there was positive support for the important idea that different psychological processes and traits are needed in learning existing knowledge in a typical school-like situation than are required in a research participation situation where the central task is to produce new knowledge.

ERIC No.

18. SOURCE OF ABSTRACT

C. FUNDING DATA

19. SUPPORTING ORGANIZATION

20. DIVISION OR DEPT.

21. CONTRACT NO.

PROJECT NO.

22. TOTAL COST OF PROJECT

23. DURATION OR PROJECT

U.S. Department of Health, Education, and Welfare
Office of Education

2

ED001189

IDENTIFYING HIGH SCHOOL STUDENTS WITH CHARACTERISTICS NEEDED IN RESEARCH WORK

April, 1963

Department of Psychology
University of Utah
Salt Lake City, Utah

REPRINTED BY PERMISSION
U. S. DEPARTMENT OF HEALTH, EDUCATION AND WELFARE
OFFICE OF EDUCATION

THIS DOCUMENT HAS BEEN PRINTED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL OFFICE OF EDUCATION POSITION OR POLICY.

ED001189

Identifying High School Students with Characteristics Needed in Research Work[1]

Chapter 1

Introduction

In the course of our research and the research of others on the nature of creative and productive scientific talent, there is growing evidence that the abilities required in typical academic, school-like learning activities do not overlap--in fact, may even be relatively independent from--the abilities needed to produce and perform successfully in research activities (Holland, 1961; MacKinnon, 1962a, 1962b; Mullins, 1962; Taylor, Smith, Ghiselin, & Ellison, 1961; and Yamamoto, 1961a, 1962). Further study is certainly indicated in this general area which underlies many current and projected national programs on scientific manpower and education.

It is of great potential value to the nation to obtain further insights into this area in order that (1) losses of the most relevant types of manpower needed in research work in scientific laboratories can be reduced, (2) the most relevant types of talent will be developed in our educational programs, and (3) such talent will be most fully utilized to speed up scientific progress in the nation.

Our studies of Air Force and National Aeronautics and Space Administration (NASA) scientists have yielded a list of characteristics needed in actual research work. (Taylor et al, 1961, Taylor and Ellison, 1962). This list of characteristics differs in many respects from characteristics usually found to be the most valid in the typical academic situation. Since many of the above studies have utilized on-the-job scientists, there is a general need to extend these studies to determine whether or not similar findings would emerge with high school students. In addition, a criterion question arises as to whether, and under what conditions, these same characteristics will manifest themselves in high school students.

In an attempt to answer this need for extending these studies to earlier age groups, we conducted a study of nine National Science Foundation summer science programs for high school students during the summer of 1961. Two main types of summer science programs were studied, the academic type and the research-participation type. In the academic-type programs, the students received an advanced treatment of subject matter and laboratory exercises, generally in the biological or physical sciences. In the research-participation type the students worked on research problems of their own choice or they joined ongoing projects as junior members of a professional research team.

---

[1] Support By The National Science Foundation under Contract No. NSF-C17543. Monitor, Howard Hausman.

The authors gratefully acknowledge the following people who assisted in this project: Elwin Nielsen, Robert L. Ellison, C. Victor Bunderson, Clifford Abe, Madge Nickel, Louis D. Gusto, Walter Needham, Janice Rigby, Bill Gibson, Larry Aleamoni, and Connie Tramell.

There was a special interest in studying students from these research-participation programs since it appeared that these research activities would provide an opportunity, if not actually require the students,to display characteristics which more closely resemble those characteristics actually required on the job in science,than would the more school-like summer programs.

The purpose of this study was two-fold: (1) To determine whether the creative and productive characteristics found for scientists on the job, as discovered in recent studies of Air Force (Taylor et al, 1961), Space Agency (Taylor & Ellison, 1962; Ellison, 1962), and other scientists (Taylor, 1956, 1958, 1959; Taylor & Barron, 1963) were measurable in samples of high school students in the research and academic types of summer science programs,and whether these same characteristics were related to the performance of the students in these activities; and (2) to determine to what extent these new selection measures would differentially predict success in these two types of programs.

It was our expectation that if these characteristics were identifiable in high school students, they would be more valid predictors for the research participating programs, whereas the more traditional selection devices such as IQ and past academic achievement (which are generally used in the selection of the students who attend all of these summer programs) would be more valid in the academic-type program.

This study provided a unique opportunity for investigating these important questions. Other methods would have either involved more fallible criterion measures, i.e., ratings on research ability and potential during the course of the students' regular academic training, or a costly program in both time and money in which the students would be tested during the High School training and then followed up until a significant percentage had graduated from college and worked in research environment a sufficient amount of time so that adequate criterion data could be obtained. In other words many of the advantages of such an extended program of research have been captalized on in only a one year study.

Academic Sample

The sample for the academic programs consisted of 114 (74 males, 40 females) NSF summer science high school students participating in three academic-type programs located in different geographic areas. The programs that were included in this analysis were: Augsberg College (Chemistry), C. R. Agre, Director; Syracuse University (Biology-Zoology), A. T. Collette, Director; and Washington University (Biology), J. W. Crenshaw, Jr., Director.[2]

Research Sample

The sample for the research programs consisted of 172 (143 males, 53 females) NSF summer science high school students participating in four research participating-type programs also located in different geographic areas.* The research programs that were included in this analysis were: A & M College of

---

[2] One additional program (N=28) was excluded from the analysis of the academic programs due to a lack of criterion information.

* Appendix A contains a list of titles of student's projects.

Texas (Biological Sciences), John J. Sperry, Director; Committee for Advanced Science Training at Los Angeles (Biomedical Sciences), Harry Sobel, Director; Roswell Park Memorial Institute (Multiple Sciences), E. A. Mirand, Director; and University of Pittsburgh (Biology, Bio-chemistry), John R. Jablonski, Director.[3]

The students in this type of program are, in effect, junior members of a team actively engaged in scientific research under the direct supervision of a senior scientist. A list of some of the research projects being done by these students is presented in Appendix A. To indicate the complexity of the research products of these high school students, a few paragraphs from different reports are presented in Appendix A.

The students in both types of programs were selected by the individual directors for participation in these programs largely on the basis of IQ and high academic achievement in their respective high schools.[4] In general, the academic programs were more highly selected on these variables than were the research-participation programs.

Some of these programs only accepted students from their immediate locality while others accepted students from all parts of the nation.

---

3. One additional program (N-24) was excluded from the analysis of the research programs due to results which were extremely conflicting and inconsistent with the results of the other groups. The correlations were much the same as in the other groups except that they were in the opposite directions. For example, we have one predictor, our Biographical Miscellaneous Key, which at best has had very low relationship with criteria of research performances in past studies on mature scientists. In the present study this predictor correlated highly with performance in the academic groups and did not correlate with performance in any of the research groups except on this one conflicting research sample. Over the entire set of data there were so many conflicting results such as this one, that a great deal of checking was done. The scoring of the tests, the recording, the computer input and output, and all aspects of the data processing were checked by hand to see if an error had been made, but none was found. One possibility is that for some reason a large proportion of the supervising scientists at this one program reversed the rankings and the rating scales, rating high students low and vice versa, even though the rating scales were well constructed. It is admitted that the results on this sample remain largely unexplained, especially in view of the fact that all the other samples were so consistent with each other. We attempted to contact the personnel at this program in order to revisit them during another eastern trip and explore whether anything had gone wrong in the data collection process. However, such arrangements did not materialize and a revisit unfortunately has not yet occurred.

4. "Admission to the summer programs will be determined by the sponsoring institution, not by the National Science Foundation. In general, selection will be based upon scholastic ability, science motivation, and the completion of specified high school courses in science and mathematics." Quotation is from the Summer Science Training Program for High Ability Secondary School Students. National Science Foundation, 1961.

In order to compare the more traditional measures or indicators of talent to the criteria and to the other "newer" predictors, three predictor scores were taken from the high school transcripts of the students: a grade-point average for non-science classwork; a grade-point average for science classwork; and an IQ score when available.

These three variables then were included in this study to determine if these more traditional selection devices would, in fact, be more valid for the academic programs than for the research program and also to determine if GPA and IQ are valid predictors of creative and productive performances in students at this age level. However, several studies have shown that school grades and IQ scores have little validity in the prediction of creative and productive performance and at best account for only a small amount of the variance (Getzels and Jackson, 1959; Torrance, 1959, 1960; MacKinnon, 1962; Taylor et al., 1961; Business Week, February 24, 1962; Holland, 1961).

Aptitude Tests. The aptitude tests included in the predictor battery were chosen on the basis of the work of Guilford (1959), Getzels and Jackson (1959), Torrance (1959, 1960), and our own study of Air Force scientists (Taylor, et al, 1961). Such aptitude tests have been used to measure high-level abilities such as originality, redefinition, sensitivity to problems, flexibilities, fluency of ideas, fluency of associations, elaboration, and evaluation measures.

The results of the creativity aptitude tests at the adult level have at best been only moderate (Chorness and Nottelman, 1957; Taylor, et al., 1961; and Mullins, 1962). Since conflicting results have been obtained in the use of these aptitude tests, there is still some question as to their validity in predicting success in science.

At the younger age levels these tests have shown considerable promise in several studies (Getzels and Jackson, 1959; Torrance, 1959, 1960; and Yamamoto, 1961, 1962). Their "promise" has been determined in terms of their construct validity and by the fact that they measure other abilities not included in the traditional measures of intellectual achievement. In these studies there have usually been no external criteria used other than academic achievement, since obtaining criterion measures on these younger age groups is extremely difficult, as pointed out before. Thus, we felt that the summer science programs would provide an excellent opportunity to validate these tests on a younger age group using external criteria of both academic and research performance.

Satisfactory Achievement Scale (SAS). This instrument is a minimum aspiration scale on which the students were asked to mark the lowest degree of each achievement with which they would be satisfied for the rest of their life on each of thirteen aspiration scales. In our study of Air Force scientists, it was found that this simple aspiration scale had a considerably higher percentage of significant validities than did a much more complex motivational device (Taylor et al., 1961). Holland (1961) also reports that simple interest and motivational measures are among his best predictors of creative performance.

Self Description (SD) Scale. On this instrument each student was asked to rate himself as compared with other students on seventeen characteristics using a seven-step scale. In the Air Force scientist study, this instrument proved to be the second best predictor of the factored multiple criteria, both in terms of the number and magnitude of the validity coefficients. Twelve of the scales proved to have significant correlations with the 17 criteria of successful research performance.

In our studies of large samples of NASA scientists, this instrument has been converted to fit a multiple choice format and has consistently provided some of the best items in the identification of creative and productive performance.

NSF Biographical Information Inventory (BII). In our studies of the relation ship of biographical information to success in science, over 1,600 scientists have filled out one of our 300-item multiple choice questionnaires. The vast majority of this work has been conducted in conjunction with NASA. In a broad sense, the BII attempts to measure as much of the past environment in life history as possible, with the expectation that prior experience will relate to present and future behavior.

Prior to the NASA project, two studies had been conducted at Utah to explore the relationship of biographical information to scientific accomplishment, one by Ellison (1960, 1962), and one on Air Force scientists (Taylor, et al, 1961). No cross-validation was attempted in either of these preliminary studies in view of the relatively small sample sizes, but the best items from both studies were identified and were retained for future use in the NASA project.

The same instrument that has been used in our NASA studies was also used in this study of high school students with the exception that revisions were made to adapt it for use at the high school level. It was found that the majority of the biographical items which were written for administration to mature scientists could also be administered to high school students. Other items had to be re-written so that they appeared appropriate for high school students. Some of the items, which unfortunately came from the most valid section of the BII, had to be eliminated because they were not appropriate for high school students.

The use of biographical information has been one of the most promising areas in the identification of creative talent (Roe, 1951, 1961; D. Taylor, 1958; Sprecher, 1958; Ellison, 1960, 1962; Smith, Albright, Glennon, and Owens, 1961). In the Air Force study, this type of instrument was clearly the best all-around single predictor of the multiple criteria (Taylor et al., 1961). In the NASA studies this instrument has consistently given cross validities from the high forties to the high fifties across different research centers and across different criteria (Taylor & Ellison, 1962).

National Merit Scholarship Corporation (NMSC) Form. This instrument is a combination of self-ratings, checklists of background and interests, preferred activities, and levels and kinds of past achievement that have been developed for research purposes by the National Merit Scholarship Corporation and has shown some promising results in the identification of creative talent (Holland, 1961). Holland has used this instrument as a criterion of creative performance in high school students; therefore, we felt that such an instrument should also work well as a predictor so we adapted sections of the form developed by Holland as part of our predictor battery.

Criteria

An attempt was made to collect criterion measures on the students in both the academic centers and the research centers that were similar to those used in studies of on-the-job scientists, with appropriate modifications for the summer training programs. It was our expectation that the criteria used would be more appropriate for measuring research performance than they would be for the measurement of academic performance since such criteria are not generally used to measure academic performance. In fact, the degree to which all such behaviors would be observable in academic programs was somewhat debatable.

Peer Ranking Form (Criterion #1). On this form, each student was asked to rank his peers into one of five categories on the basis of overall productivity in their respective programs. The students were instructed to place approximately one-fifth of the students into each of the five categories and then to circle the top three students in the first category and the bottom three in the last category, thus yielding a seven step-scale of overall productivity.

Overall Ranking by Supervisor (Criterion #2). This form is identical to the peer ranking form and the same instructions that were given to the students were also given to the various supervisors. In two of the research programs this form could not be used since the senior scientists only worked with one or two of the students and were not familiar with the work of the other students.

NSF Evaluation Form. This measure was constructed for this project on the basis of the results of our own studies of Air Force and NASA scientists. Eight characteristics which appeared to be important characteristics for achievement in science were selected and constructed into rating scale form. The supervisors were asked to rate each student on each of the eight characteristics using a seven-step scale. The form included ratings on Drive (Criterion #3), Cognition (#4), Informative Ability (#5), Flexibility (#6), Persistence (#7), Independence (#8), Cooperation (#9), and Creative Ability (#10).

NSF Assessment Form. On this form the supervisors were asked to rate each student on five characteristics using a seven step scale. This form, which was constructed for this project, was adapted from the work of Donald Taylor (1958), who developed the form for the assessment of creativity and productivity in Navy scientists. Modifications of this scale and also a checklist of creative characteristics developed by Calvin W. Taylor have also been used as criterion forms in Taylor and Ellison's NASA studies. This form included ratings on Quality of Work (Criterion #11), Initiative (#12), Originality (#13), Attitude toward Work (#14), and Skill in Getting Along With People (#15). Some modification of these scales was necessary since certain of the statements required performance above what could be expected of high school students just entering into research activities.

Control Scores.

In addition to the predictor scores and criteria ratings, control scores were used to insure that any results which might be obtained were not artifacts of certain obvious background factors. The control scores used were Age, Sex, Father's Educational Level, and Number of Science Courses Taken.

CHAPTER 2

Procedure

Two visits were made to each summer program. The first visit, at or near the beginning of each program, was for the purpose of administering the predictor battery and also to acquaint the directors and students with the nature and scope of our project. To avoid any bias, the students did not receive any detailed information about this research project until they had completed all phases of the testing.

The predictor battery was divided into two parts, a timed aptitude section and a "take home" section. The timed section consisted of 12 Guilford-type creativity aptitude tests. For this section, the students were assembled in a classroom and were tested under closely timed and supervised conditions. The "take home" section consisted of the SAS, SD, BII, and NMSC forms. Whenever the students did not have sufficient time to complete this section within the "assembled" testing time allotted to us by the directors, they were allowed to take home that portion which they had not completed and return it to us the following day.

Our second visit was for the purpose of collecting criterion information on the performance of the students. It was made at the termination of each program so that the various supervisors would have as much time as possible to become familiar with the performance of each student. At each program, our representative met with the various supervisors to explain each criterion form. He also met again with the students to explain and to give instructions for the peer nomination form.

CHAPTER 3

Results

Criteria

Since the criteria were primarily designed for the research programs, it was our expectation that we would obtain only a global success rating from the use of these criterion scales in the academic programs; that is, high achievers in the academic program would tend to be given high creativity ratings by their actual creative ability. The same would be true of other non-academic ability traits. However, from the results presented in Table 1 and 2, it is clear that fourteen of the fifteen criteria are quite highly intercorrelated in both programs. All tables are assembled together at the end of the report. The last criterion score, Skill with People, was only moderately intercorrelated with the other criteria but it was also the least predictable. Therefore, in discussing the predictor battery for the two programs, it is evident that we are talking in terms of a global success criterion rather than the validity of any one predictor against any one criterion.

Even though high intercorrelations among the criteria were obtained in both types of NSF samples, it can be seen from Tables 1 and 2 (at the end of the report) that in all but one case the means were lower and the standard deviations larger for the criterion scores in the research sample than they were in the academic sample (not necessarily statistically significant differences though). Thus, this is one indication that the criterion characteristics were more observable in the research participation programs than they were in the academic programs.

Predictors, Grade-Point-Average and IQ. In the academic sample (Table 3) both the Science and Non-Science GPA scores were significantly correlated with 8 of the 15 criteria and IQ was significant for 5. From Table 3 it can be seen that by using all three of these predictor variables, significant validity coefficients are obtained with 12 of the 15 criteria. In the research sample both the Science and the non-Science GPA scores had significant correlations for 14 of the 15 criteria and again IQ was significant for 5. The results for these scores on the research sample are presented in Table 4. The greater variability in the criterion scores on the research sample may have made them somewhat more predictable than the criterion scores on the academic sample.

Table 5 gives comparisons between the academic sample and the research sample on the Science and Non-Science Grade Point Average and IQ scores. It may be noted that on non-Science GPA and IQ the academic and research samples were significantly different in favor of the academic sample, while on Science GPA they showed no difference.

Aptitude Tests. The results of the aptitude tests for the academic sample are presented in Table 6. Six of the 23 scores that were obtained from the 12 aptitude tests were eliminated from this analysis because of high intercorrelations with the other Aptitude test scores. Of the remaining 17 Aptitude test scores, 6 had significant positive correlations with 8 or more of the 15 criteria. Revision II-Ideas (the best test from our communication abilities study and probably in the convergent thinking area) was the best aptitude test, being significantly correlated with 14 of the 15 criteria; Vocabulary (verbal comprehension) was significant with 13; Gestalt Transformation (conceptual redefinition) was significant with 9 as was Match Problems (adaptive flexibility); Visual Imagery (not yet factored but probably in the divergent thinking area, since its scores correlated .52 with Match Problems), and Pertinent Questions (conceptual foresight) were significant with 8 criteria. Revision II-Words was valid for five criteria as was the Revision II-Words/Ideas.

The test, Plot Titles, had significant correlations with 2 criteria and Compound Words with 1. The other tests, Plot Titles (ideational fluency), Brick Uses (ideational fluency), Brick Uses (flexibility), Planning Elaboration, Apparatus, and Meaningful Statements, failed to demonstrate any validity with the criteria in the academic sample.

The results of the aptitude tests in the research sample are presented in Table 7. As in the analysis of the academic programs, the same 6 aptitude scores were also eliminated in this sample due to high intercorrelations with other aptitude test scores. Six of the remaining 17 aptitude test scores had significant correlations with 2 or more of the criteria. The Vocabulary (verbal comprehension) test was significantly correlated with 13 of the 15 criteria, Visual Imagery with 6. Gestalt Transformation (conceptual redefinition) was significant with 4 criteria, while Plot Titles (Originality) was significant with 2. Meaningful Statements (not factored) was significant with 2 of the 15 criteria. The tests, Pertinent Questions, Plot Titles (fluency), Match Problems, Apparatus (fluency), Apparatus (originality), Compound Words, Brick Uses (fluency), Revision II-Ideas, Revision II-Words, Revision II Words/Idea, and Planning Elaboration were not significantly related to the criteria in the research sample.

Comparisons between the academic and Research Samples on the aptitude tests are shown in Table 8. Only 1 test, Meaningful Statements, gives significantly different mean scores between the two groups, in favor of the academic sample.

Satisfactory Achievement Scale. Table 9 shows that in the academic sample, 6 of these SAS scales had significant validity coefficients with 3 or more of the criteria. The aspiration scales on Reading Ability and Writing Ability were both significantly correlated with 13 of the 15 criteria; Level of Original Work was significant with 11; Listening Ability was significant with 8; Speaking Ability was significant with 6 while Theoretical Contributions was correlated significantly with 3 of the 15 criteria and Actual Practice was correlated with 1. The scales, Quantity of Work, Administrative Ability, Being Well-Liked, Being Well-Known, Experimental Contributions, and Quantity of Published Reports did not yield any significant validity coefficients in the academic sample.

From the results presented in Table 10 it can be seen that 9 of the SAS scales were significantly correlated with 2 or more of the criteria in the research sample. Quantity of Published Reports was significant for 13; Level of Original Work and Speaking Ability were both significant for 10 of the 15 criteria; Experimental Contributions was significantly related to 9 criteria;

Theoretical Contributions was related to 8, Administrative Ability was significant in the negative direction for 4; Writing Ability was significant for 2; Being Well Liked was significant (negative) for 2; Listening Ability was significant for 1 criterion,and Reading Ability, Quantity of Work, and Being Well-Known were not significant with any of the criteria.

Table 11 shows comparisons between the academic and research samples on the SAS mean scores. Only 1 test, Quality of Published Reports, gives significant differences scores between the two groups, in favor of the research sample.

National Science Foundation Biographical Information Inventory (NSF-BII). From an item analysis of the BII administered to 357 NASA scientists, 7 scoring keys were constructed for cross-validation on future NASA samples. These same 7 keys were used to score the BII that was administered to the NSF summer science students' however the items which had been either eliminated or re-written for the BII for the summer science students were eliminated from the scoring keys for the NSF students. This means, that an item must have appeared in both the adult form and the NSF form and must also have been keyed on the adult sample in order to be scored on the NSF sample. The 7 keys used to score the BII were: General Intellectuality, Independence, Professional Self Confidence, Miscellaneous (composed of items that could not be classified into one of the first 3 areas but had validity with the NASA criteria), Form A Total Creativity Score (sum of the first 4 keys), Extent of Experimentation and Participation (participation in science-like activities during youth), and Form B Total Creativity Score (a key which was built from the second administration of the BII to a sample of 300 NASA scientists at a different research center using different criteria with the first 4 areas collapsed into one score).

Table 12 shows that in the academic sample, 4 of the 7 scoring keys derived from our NASA studies had significant validity coefficients with 3 or more of the criteria. The Form A Miscellaneous Key had significant validity coefficients with 6 of 15 criteria, as did the Form B Total Creativity Key. Form A Total Creativity Key was significant for 5 of the 15 criteria. Form A Intellectuality Key was significant for 3 criteria and Form A Independence Key had 1 significant validity coefficient. The keys for Professional Self Confidence and Extent of Participation did not yield any significant correlations with the criteria in the academic sample.

The results of the BII, for the research sample are presented in Table 13. Five of the 7 scoring keys derived for this instrument were significantly related with 11 or more of the 15 criteria. The Form B Creativity Key was significant with 14 of the 15 criteria, Total Creativity (Form A) was significant with 13, Independence was significant with 12, the key Intellectuality was significant with 11, Professional Self Confidence was significant with 10 and the key for Extent of Experimentation was significant with 2 criteria. The Miscellaneous Key failed to yield any significant correlations with any of the 15 criteria in the research sample.

Table 14 shows that 2 of the 7 BII keys produced significantly different mean scores between the academic and research samples, with the Miscellaneous Key in favor of the academic sample and the Extent of Experimentation Key in favor of the research sample.

Self Description Scale. The results of the SD's are presented in Table 15. This instrument, which takes only a very few minutes to administer, again proved to be a valuable instrument, with 8 of the 17 scales having significant correlations with 3 or more of the criteria in the academic sample. Desire for Principles had significant correlations with 12 of the 15 criteria, Drive was significant for 10, and Cognitive Ability was significant for 7. Flexibility was significant for 6 criteria in the positive direction and 1 in the negative direction. Independence for 4, Math Ability and Persistence were both significant for 3 of the fifteen criteria. Self ratings on Cooperation were significant for 2 criteria. Self ratings on Informative Ability, and Resourcefulness were significant for 1 criteria. Quality of Skill in Design, Discrimination of Value, Desire for Facts, Desire for Discovery, Intuition, and Creative Ability did not yield any significant validity coefficients in this type of program.

Table 16 shows that the SD scales worked very well in the research programs with 9 of the 17 self rating scales having significant correlations with 7 or more of the criteria. Self ratings on Drive were significant for 15 and on Cognitive Ability for 12 of the criteria. Desire for Principles was significant with 10 of the 15 criteria. Desire for Discovery was significant with 9 and Desire for Facts was significant for 7. Discrimination of Value was significant for 7 criteria, while self ratings on Resourcefulness, Integrity, and Creative Ability were all significant with 3 of the criteria. Informative Ability, Quality of Skill in Design, and Flexibility were all significant with 1 of the criteria. Self rating on Cooperation had one significant negative correlation with the criteria, and only one self rating scale, Intuition, was not significantly correlated with any of the criteria (even though it was one of the more valid scores on our Air Force scientists).

Comparisons of mean scores between the academic and research samples are shown in Table 17. There were no significant differences on the self-ratings between the two groups.

NMSC Form. Of the 25 scores derived from this form only 6 proved to have significant validity with 2 or more of the criteria in the academic sample (Table 18). Judgmental ratings on Originality of a Written Essay had 7 significant validity coefficients; self rating on Scholarship was significant for 7; Daydreaming of High and Creative Accomplishment was significantly correlated with 4 of the criteria; self ratings on Self Understanding was significant for 3.

The results of the NMSC form in the research sample are presented in Table 19. Of the 25 scores derived from this form, only 8 were significantly correlated with 3 or more of the criteria. Drive to Achieve in Science Activities was significantly correlated with 13 of the fifteen criteria; self ratings on Scholarship was significant with 13; Daydreaming of Work Activities had 9 significant negative correlations; Occupation Choice (science) was significant with 4; Daydreaming of High and Creative

Accomplishment was significant with 3; and NMSC Self Evaluation (number of times a person rates himself above average on 20 Self Rating scales) was significant with 3. Public Recognition for Leadership Activities and the Topic Selected for an essay (science) were both significantly correlated with one criteria. Topic Selected (politics) and the Total Number of Words used in writing the essay both had significant negative correlations with one criteria.

Table 20 shows that 3 of the mean scores obtained in the NMSC form were significantly different in the academic as compared with the research sample. The academic sample scored higher than the research sample on Emotional Stability and on Leadership Activities, but lower on Scholarship.

Control Scores

Father's Education Level. In the academic sample this variable had little effect on the performance of the students, being significantly correlated with only one criterion, supervisor's rating on Cognition (Table 21).

In the research sample (Table 22) this control score had no significant relationship with either the criteria or the predictors. It is of interest to note, however, that in the academic sample this control score, was positively (though not significantly) related to all fifteen criteria whereas in the research sample this variable was negatively (though not significantly) related to twelve of the fifteen criteria. There is, therefore, some slight indication that the student who comes from a "non-academic" background, as judged from father's educational level, tends to be the more successful in research activities whereas the reverse is true in the academic programs.

In the predictor battery, however, we found that those students who came from "academic" backgrounds scored higher on IQ and the Vocabulary Aptitude test whereas the students from "non-academic" backgrounds scored higher on the non-verbal Match Problems Aptitude test. The students from "academic" backgrounds had high aspirations for achievement in the reading and speaking skills and wanted to be well known in later life. They scored higher on the BII Intellectuality Key and rated themselves higher on Cognitive Abilities, Integrity, Independence, and Discrimination of Value. They also scored themselves as more creative than their "non-academic" peers. They participated in more creative activities such as writing stories, coining new words, designing furniture, directing a play, etc., but their "non-academic" peers had received more public recognition for leadership activities.

Age. In the academic sample this variable was not too surprising. From our results, it was definitely the younger student who was the more successful in this type of program. Age was negatively correlated with thirteen of the fifteen criteria, although it was only significant for six (Table 21). While the supervisors considered the younger student to be the more successful, his peers did not. Peer ranking on Overall Productivity was positively related to age. In the predictor battery we also found several significant correlations with age in the academic sample. The younger student obtained higher IQ scores (probably one reason for his success) and scored higher on the vocabulary aptitude test. He had higher aspirations for achievement in the reading and speaking skills and expected to produce a large quantity of work in later life. He rated himself higher on Cognitive

Abilities, Informative Ability, and Resourcefulness and had also participated in more creative activities than had his older peers.

In the research sample (Table 22) there was also a trend for the younger student to be the more successful since age was negatively correlated with twelve of the criteria although only two of these correlations were significant. Again, as in the academic sample, the students in their peer ratings disagreed with the supervisors since they felt that the older student was the more successful. Across the predictors this variable of age had significant correlations with only three of the predictors. The younger student scored higher on IQ and also scored higher on the BII Intellectuality Key. We also found that the younger student rated himself as less conservative than his older peers.

Sex. With the criteria in the academic sample we found only one significant sex difference and that was with Originality in favor of the males (Table 21). In the research sample we found no evidence of a sex difference on the fifteen criteria (Table 22).

Across the predictors we found several sex differences in the academic sample. As expected, the females scored higher on IQ. On the Aptitude tests there were no significant sex differences. In spite of the fact that the aptitude battery included tests of verbal and spatial and mathematical skills, which often show sex differences. On the Satisfactory Achievement Scale, the males had higher scores on Aspirations for Achievement in Speaking Skill, Wanting to be Well Known in Later Life, and expecting to make a considerable Number of Theoretical Contributions in their particular field of endeavor. On the BII the males scored higher on the Professional Self Confidence Key and Extent of Experimentation and Participation Key. On self descriptions, the males rated themselves higher on Math Ability, Design Skill, more independent, more resourceful, and higher in Creative Ability than did the females. On the NMSC form females tended to daydream about regular work activities while the males daydreamed about high and creative accomplishment. The males rated themselves as more original and more independent but the females had received more public recognition for accomplishment in the area of art work. It is interesting to note that there was no sex difference for public recognition of leadership and science activities. When given various topics to write about, the males selected science topics while the females prefered to write about education. Although the females wrote more about their topics there was no difference between the two groups on how original their writing was.

We obtained some significant sex differences on the various predictors in the research sample, but not to the extent that occurred in the academic sample. The males had higher GPAs in science courses while the females obtained higher IQ scores. We found only one sex difference across the various Aptitude tests and that was on Gestalt Transformation in favor of the males. On the SAS the females had higher aspirations for being well known in later life while the males expected to make more theoretical contributions to their future specialty. On the BII the females scored higher on the Independence Key while the males scored higher on Extent of Experimentation and Participation. We obtained no sex differences on the Self Description Scales. On the NMSC form, however, we found that females had participated in more creative activities and they tend to daydream about helping others. More males chose science as a future occupation than did females. As in the academic sample, the females had received more public recognition for their art activities but there was again no difference between males and females in receiving public recognition for leadership and science activities. Females again chose to write about education when given a choice of various topics on which to write about. They wrote more than did the males but there was no difference between these two groups on how original their essays were.

Number of Science Courses Taken. This score was obtained from the students' transcripts and was simply a count of the number of science courses each student had taken since the 9th grade.

In the academic sample (Table 21) this score had significant negative correlations with 4 of the 15 criteria, again indicating that the younger student was the more successful. Across the predictors in the academic sample we found that the students who had taken the most science courses in school scored lower on IQ and on the Meaningful Statements Aptitude test. On the BII this type of student scored higher on the Intellectuality and Extent of Participation and Experimentation Keys than did his peers who had not taken as many science courses.

In the research sample this variable had significant correlations with three of the criteria but unike the academic sample their correlations were positive, indicating that a background in science is more important for research activities than it is for academic activities.

Across the predictors in the research sample the "science" student scored higher on the Plot Titles aptitude test, did not have high aspirations for Being Well Known in later life, and did not want to follow one of the practicing professions such as medicine or teaching. He was more involved in science-like activities during his youth and rated himself high on Cognitive abilities, Design Skill, Discrimination of Value, and Desire for Facts. He had also participated in more creative activities than did his peers who had not taken as many science courses.

Chapter 4

Discussion

Criteria

From the results presented in Tables 1 and 2 it can be seen that within both samples the criteria were highly intercorrelated. We expected to obtain high intercorrelations in the academic sample since there was a question as to whether or not the characteristics that our criteria called for would be very observable and therefore distinguishable in the academic setting. However, we expected to obtain more independent ratings in the research sample since the traits measured by the criteria should be more individually observable, and probably, more required of students in research activities. In an analysis of the individual programs we found that in some of the research programs the intercorrelations of the criteria were much lower. However, when all of the research programs were combined into one sample, the intercorrelations went up considerably.

There was evidence of rater bias in the criteria in both samples. Superior students tended to be rated high on all traits and poor students tended to be rated low on all traits. This, of course, may be the main reason for the high intercorrelations that were obtained among the criteria. The criterion distributions were negatively skewed. This skewness was more evident in the academic sample than it was in the research sample. Perhaps, one reason for this skewness is that the students who were admitted into these programs were highly selected. Therefore, their supervisors also considered the students to be superior on the criterion traits used in this study.

In the research programs we encountered two other problems which effected the criteria. For some of the senior scientists this was the first time that they had ever worked with high school students in research. These scientists found that rating the students was rather difficult since they had no prior reference group on which to base their ratings. Other scientists expressed concern about the ratings appearing on the students' records. Therefore, they did not like to rate the student lowly since they felt such ratings could effect the future endeavors of the students, even though our criterion scores were collected for research purposes only.

There was also some evidence of restriction of range in both the criteria and the predictors resulting from homogeneous grouping. The fact that the variables typically used in the selection of the students for these programs, of IQ and past academic achievement, showed a restriction of range but also had significant correlations with the criteria, indicated that there was some homogeneous grouping on the criteria. When the mean scores on the aptitude tests and the biographical keys for both NSF samples were compared with the mean scores on these same predictors on a random sample of Salt Lake City high school students, there was further evidence of restriction of range in both the NSF samples on some of the aptitude tests and on six of the seven biographical keys. (Tables 23, 24, 25, 26). Although the other predictors were not statistically compared among these three groups, we assume, from visual inspection that the same was also true for the other predictors used in this study.

Even though the criteria obtained in the present study left something to be desired, we felt that the information obtained was very valuable since the opportunity for obtaining any criteria at all on the research performance of students at this age level is very rare. The fact that the results of this study are in general agreement with other studies conducted on adult samples of scientists, indicates that even though our criteria were not the best, they were somewhat representative of actual criteria of research performance. They should, therefore, be instrumental in developing predictive instruments for school students with exceptional research potential.

We are now in the process of conducting our second study on high school students in research activities with the hope of at least replicating, if not improving upon, the results of the present study. One of the major goals of this second study is to obtain more reliable, valid, and differentiated criterion measures on the performance of these students in their research activities. In this second study, using the knowledge obtained from working with this year's data, we have modified the best forms used in the present study, built new criterion forms, and worked with the individual scientists trying to eliminate some of the biases and error that became evident in the present study.

G.P.A. and IQ. From the results of this study it is quite clear that even with the moderate correlations obtained, past academic achievement and IQ are some of the best all-around predictors of success in the academic sample. Such results from these variables in the academic sample were expected since past academic achievement should predict future academic achievement quite well and also because IQ tests were often constructed to measure the kinds of achievement displayed in typical school activities.

The moderate correlations between the criteria and past academic achievement and IQ may be partly explained on the basis of restriction of range since the mean scores for these variables indicate that we are dealing with only part of the total variance. That is, we would expect these correlations to increase in samples having a wider range of predictor variance. However, these moderate correlations may also be partly due to the fact that the criteria used in this study are quite different than those generally used to evaluate academic performance. Thus, past academic performance and IQ may not be as important in the types of activities called for in our criteria as they are for traditional academic performance.

In the research sample, past academic achievement was also a good predictor of research performance. In fact, it was more valid both in terms of the magnitude and number of the significant validity coefficients than it was for the academic sample. This difference in favor of the research sample may again be partly due to greater restriction of range in the academic sample. From the results presented in Table 5, it can be seen that the students in the academic sample had significantly higher mean GPAs and smaller standard deviations than did the students in the research sample.

The correlations between the two GPA's (science courses and non-science courses) with the criteria in the research sample are somewhat higher than has been the case in studies of adult scientists previously cited. These higher correlations may be due to the fact that these students are just entering into research activities and must learn new subject matter and techniques in order to perform their research. Thus, academic abilities, especially vocabulary ability (verbal comprehension), may still be important factors in initial research performances (initial orientation to jargon, etc.) at this age level. Thus, the idea is then, that there is an initial period during which the individual is becoming oriented to the jargon and learning some of the very basic subject matter often available in technical verbal form. After a certain amount of such learning is achieved, the individual apparently is more ready to apply himself to productive research which involves a different set of abilities than was used in the first brief orientation stage. To emphasize this point we might say that he was memorizing vocabulary (essentially a reproducing process) but now he is producing as a researcher, so that the earlier importance of verbal comprehension ability is fading while other abilities needed to produce new knowledge are rising in importance.

In the research sample, IQ was significantly correlated with 5 of the 15 criteria but the correlations were slightly lower than those reported for the academic sample. This finding is rather interesting since, as it happened, the mean IQ score for the academic students was significantly higher than the mean IQ score for the research students. This suggests that IQ plays a more important role in academic activities than it does in research activities.

The correlations obtained in the research sample between IQ and success in research activities are in agreement with other studies previously cited and again indicate that, in highly selected sample, IQ accounts for only a part of the total variance of research performance.

Some investigators have suggested that beyond a certain level, IQ has little relationship to creative ability (Getzels & Jackson 1959; Torrance 1959, 1960; Yamamoto 1961, 1962; MacKinnon, 1962a, 1962b). The results of the present study suggest that the same may be true in the initial stages of research activities. However, further studies are needed to determine the lower limits of intellectual performance, as measured by IQ tests, which are necessary for successful performance in research.

There was also some measurement error in the IQ score that was obtained in both samples. In many of the cases the student transcripts gave no indication from which test the IQ score was obtained. Thus, it was not possible to take special steps to equate the various IQ test scores. This, of course, resulted in measurement error and might alter the validity coefficients for this variable. Since this error existed in both training programs, it still could not explain the differential validity patterns obtained across the two programs.

Aptitude Tests

The aptitude tests proved to be the second best set of predictors in the academic sample with 39 per cent of the validity coefficients being significant. Six of the tests, Revision II-Ideas, Vocabulary, Match Problems, Gestalt Transformation, Visual Imagery, and Pertinent Questions, all proved to be significantly correlated with 8 or more of the criteria. Only 2 of these tests, Match Problems and perhaps Visual Imagery, fall into the divergent thinking area. The other 4 tests are found either in the memory or convergent thinking area.

The results of the aptitude tests in the research sample were very disappointing with only 12 per cent of the validity coefficients being significantly correlated with the criteria.

The lack of validity of the aptitude tests in the research sample supports the findings of Taylor et al (1961), who reported a relative lack of validity of any of the multiple scores taken from the 7 high-level aptitide tests in his study of Air Force scientists. These results were somewhat puzzling since these tests had been selected to measure presumably important characteristics in scientists such as adaptive flexibility, originality, conceptual foresight, and not all sensitivity to problems.

One possible explanation for the low validity of some but not all of these particular aptitude tests, Taylor concluded, was the previously mentioned factor of restriction of range, either through high selection and homogeneity of the sample of these characteristics or through shorter time limits on the tests. Taylor's comments also apply to the present study in which these creativity aptitude tests again yielded low validities. The shorter time limits were again used for some of the tests in the present study and from the results presented in Tables 23 and 24 it can be seen that when the mean scores for the NSF samples are compared with the mean scores of a Salt Lake City sample of randomly selected senior high school students, there is evidence of restriction of range in 9 of the tests for the academic sample and 8 tests for the research sample. In the Plot Titles (originality) score, restriction of range in both the local and the NSF samples occurred at least in part because of overly rigid standards used by the correctors.

The obtained low validities are also due to the fact that the majority of these tests are relatively pure, measuring single independent factors, whereas the criteria are more complex factorially. Thus, one could not expect a single factor to account for a great deal of the variance of a complex criterion. The above comments however, do not explain the fact that these tests were considerably more valid in academic samples than they were in the research sample since these comments would apply to some degree to both samples.

The results of the aptitude tests in this study seem to indicate that certain of these tests are associated with academic success rather than success in research activities. Further support of this position is given by the Getzels & Jackson (1959), Torrance (1959, 1960), and Yamamoto (1961a, 1961b) studies. In these studies, the investigators reported that in using a battery of Guilford-type creativity tests and various IQ tests, two relatively independent groups of students were identified--a high creative group and a high IQ group. Despite a highly significant mean difference on IQ, both of these groups scored equally well on standardized achievement tests. Thus, it appears that the aptitude tests are measuring abilities that are relatively independent of both IQ and success in scientific research. If so, a serious question arises as to the use of these tests as secondary or intermediate criteria of creative performance in science. Consideration should be given to the type of creative performance that these tests are measuring when they are used as such intermediate criteria.

Satisfactory Achievement Scale. In the academic sample the SAS proved to be the third best predictor instrument with 28 per cent of the validity coefficients being significant. Of the 7 SAS scales that proved to be the most valid for predicting success across the multiple criteria in the Air Force study only 3 of these scales, Level of Original Work, Writing Skills, and Reading Skills had significant validities in the academic sample (Table 27). On the other hand, it can be seen from the results presented in Table 21, that the aspirations of the research students more closely resemble those of adult scientists than do the aspirations of the academic students. In the research sample 31 per cent of the validity coefficients obtained from the SAS were significant.

Even though this instrument worked well in both programs we obtained different validity patterns on the aspirations scales across the two samples. In the academic sample a pattern was obtained which one would generally associate with traditional academic success. The successful academic student had aspirations for high achievement in the reading, speaking, writing, and listening skills. The successful research students had high aspirations for producing a large quantity of published reports, and expected to contribute large theoretical developments and understanding to their specialties. The successful student in both programs expected to produce a large amount of original work, so that this aspiration score was not as discriminating between the groups, though the mean score was higher (but not quite significantly so) for the research sample.

Biographical Information Inventory. As with the Aptitude tests and the SAS we also found a different validity pattern on the BII across the two types of National Science Student programs. Only 18 per cent of the validity coefficients from the BII were significant in the academic programs. Although the validity results of this instrument for this sample were rather low, both in terms of the number of significant validities and the magnitude of the correlations, they were not unexpectedly so. Since the keys for this instrument were empirically built on adult samplesto predict successful performance in science, rather than academic work, it was our expectation that this instrument would not be as valid for the academic type of summer program as it would be for the research type of program. This expectation was supported by the fact that the key (Miscellaneous) that proved to be one of the most valid for the academic sample has been the poorest key, in terms of validity, in our studies of NASA scientists. One of the best keys (Professional Self-Confidence) in our NASA studies, had no validity at all in the academic sample.

In the research programs, the BII proved to be the best predictor of the criteria with 61 per cent of the validity coefficients being significant. The keys that have consistently given cross validities in the high forties to the high fifties in our studies of NASA scientists were also the keys that proved to be the most valid as well as having the highest percentage valid in the research programs.

A comparison between the NSF academic and research participation sample and a random sample of SLC high school students on the BII keys showed that the NSF samples obtained higher mean scores, and in the academic samples smaller standard deviations, again suggesting some restriction of range in the NSF samples (Tables 25, 26).

Self Description. The fourth best instrument in the *academic program* was the Self Description Scale with 24 per cent of the validity coefficients being significant. The successful students in this type of program rated themselves high on Desire for Principles, Integrity, Drive, Cognitive Ability, and Flexibility. Each of these scales was significantly correlated with six or more of the criteria. These students also tended to rate themselves high on Independence, Persistence and Math Ability. These last 3 scales, however, were only significantly related to 3 or 4 of the criteria.

In Table 28 the findings for the SD in both NSF samples are compared to those for the SD in our Air Force study. These results show that the self-ratings of the research students more closely resemble those of mature scientists than do the self-ratings of the academic students.

In our study of Air Force scientists, 12 of the 17 self rating scales were valid for 4 or more of the 17 factored criteria. Of these twelve scales, 6 had more than 1 significantvalidity coefficient in the academic sample. Two self rating scales, Integrity and Persistence, had valid coefficients in the academic sample but were not valid on our Air Force study.

In the *research sample*, the SD was the second best instrument with 46 per cent of the validity coefficients being significant. The successful students in this type of program rated themselves high on Drive, Math Ability, Cognitive Ability, Persistence, Independence, Discrimination of Value, Desire for Facts, Desire for Principles, and Desire for Discovery. Each of these scales was significantly correlated with 8 or more of the criteria. These students also tended to rate themselves high on Resourcefulness, Creative Ability, Flexibility, Quality of Skill in Design, Informative Ability, and Integrity. Each of these scales was significantly related to two or three of the criteria.

Of the twelve scales that were valid for four or more of the factored criteria in the Air Force study, 11 of these scales yielded significant validity coefficients with two or more of the criteria in the research sample. The only one of these 12 self rating scales which did not prove to be significant in the research programs was Intuition.

The lack of validity and the small number of correlations of some of the scales on both the SAS and the SD across both programs is somewhat difficult to explain. It may be that the student at this age level does not place high value on these characteristics or it may be that he has not had the experience or exposure to certain experiences so that these characteristics are now entering into his self concept. Thus it may be difficult for him to make accurate appraisals of himself on these traits, if they have not been given emphasis in school.

As with the SAS and the BII, we found that the SD is a more valid predictor of research performance than it is of academic performance in high school students.

NMSC Form. This form was the most disappointing of all the predictor instruments used in this study. In the academic programs only 9 per cent of the validity coefficients were significant and in the research programs, only 18 per cent of the validity coefficients were significant However, as with the other predictor instruments, we again obtained a differential validity pattern across the two samples.

Control Scores

The age difference, with the younger students performing better than their older peers, has also been noticed by Jablonski (1962) who is a director of one of their research programs. He stated that this is due to motivation....."....the students who become well versed in this research procedure tend to be less creative unless you can maintain the stimulus of excitement. In other words, our sophomore students who come in raring to go are right now beginning to produce better, more rapidly, than the seniors in our program. But the outstanding seniors, of course, who have had a feel for this research activity are doing much better all the way around." Perhaps a most significant need of our educational program today is to find better ways to foster and develop the curiosity and the creative thinking of our students as they progress through school.

The fact that there was no significant sex difference in the academic sample on the aptitude battery was somewhat unusual, since the aptitude battery included verbal materials on which females normally score higher than males, spacial and mathematical skills on which males often receive higher scores.

Magnitude of Single Correlations and of Potential Combinations

The general range of correlations (validity coefficients) between predictors and criteria runs from .00 to .45 with a few negative correlations in the same general range. Tables 30 and 31 give breakdowns of the number of correlations between the 83 predictor scores and each of two criteria, Overall Supervisors' Ranking and Supervisors' Rating on Creativity. (From a fairly close inspection it appears that these results are generally typical of the results for the other 13 criteria.) The tables are organized to show (1) the number of correlations which are valid for the academic sample but not for the research sample, (2) the number significant for the research sample but not for the academic sample, and (3) the number valid for both samples.

Over both samples for the criterion of Supervisors Ranking, there were a total of 7 correlations above .30, 15 correlations between .20 and .29, and 20 correlations which were lower than .20 but still significant. There were 124 correlations which are not significant. Over both samples for the criterion, Rating on Creativity, there were a total of 12 correlations above .30, 27 correlations between .20 and .29, 17 correlations below .20 but still significant, plus 110 correlations which are not significant. Some correlations between predictors and other criteria were of magnitudes higher than .40, although, as it happened, there were none of that magnitude for the two criteria selected for examination in Tables 30 and 31.

There was a greater number of significant correlations for the research sample than for the academic sample, which we expected since our greatest interest and intention was to predict performances of the research sample.

Considering the total number of significant correlations which we have obtained, our experience with similar problems suggests that a multiple correlation can be computed on high school students in research programs which will usually be of the order of magnitude of .60 with the various criteria on initial validation. From our experience on other projects we would expect the cross validation multiple correlation to hold up in the .40's or .50's.

If we should restrict ourselves to differential prediction by using only those scores valid for research but not for academic performance, the multiple correlation results for the various criteria would probably decrease less than .10 points.

In either case, the multiple correlation results would not be as high for the academic sample with this set of predictors; however, other predictors of the more traditional school-talent type could be used which would yield results at least as high as those found for the research sample. We are currently engaged in a companion study similar to the present one which could provide an independent cross validation sample for the many scores in common to the two studies.

Chapter 5

IMPLICATIONS

The study has demonstrated that characteristics of students with outstanding research ability can be displayed for observation and scoring at an early age, and that students with such characteristics can begin to be identified at least as early as the high school years. It is significant that these general findings emerged in spite of the presence of a number of factors which complicated and impeded the study; for example, restriction of range in the sample; rater bias, lack of skill among raters and, in some cases, lack of much acquaintance of rater with ratee.

As has been the case in almost all previous studies of adult scientists, our revised Biographical Information Inventory is the best predictor of creative scientific talent in high school students. Several other predictors, i.e., Past Academic Achievement, Self Description, and Satisfactory Achievement Scale also worked very well.

In addition to predicting scientific research talent these instruments suggest personality and preference characteristics which are often found in conjunction with creative scientific talent. Thus the creative students in this study tended to have high aspirations for producing a high level of original work, expected to produce a large quantity of published reports and expected to contribute large theoretical developments and understanding to their specialties. Their BII responses indicate that they have many personal history characteristics similar to adult scientists; for example they see themselves as being independent, somewhat socially isolated in their lives, rather questioning and curious, somewhat self assertive, and self confident. Their histories suggest extensive tinkering or experimenting with new and scientific objects and ideas. Their Self Description tests provide clues as to their make up too; for example, they see themselves as having high amounts of math ability and cognitive ability, and as being persistent, independent, discriminating, and having a strong desire to learn facts and principles, and to make discoveries. For easy and complete comparison of the major differences between the academic and research participation groups, Table 29 shows the various scores on each test rearranged to show the number of criteria with which the scores of each group are related. Perhaps the different patterns across the two groups of subjects is one of the most significant findings, since it emphasizes that the students in both groups have different complex and important backgrounds, feelings, drives, attitudes, skills, and personalities.

Several other ideas of a general nature are implied by the results of the study. To begin with, we might consider the information which has been made available by the results of the aptitude tests across the two groups. We see that aptitude tests designed for creative performance may measure a kind of creativity that is important in one situation but not in another.

It is important to notice that this indicates that creative ability may not be simply a single global ability. Rather, creativity may be more highly specific to particular tasks, and we should avoid the trap of considering it a simple single quantity, as we once considered IQ to be. More exploration is needed to develop additional aptitude tests which are valid for the specific situations in which creative performance is required.

The Self Description Test should renew our faith in the ability of the healthy individual to understand and evaluate himself in terms of characteristics which may be brought to his attention. At the same time, since some self insights on the part of the subject are indicated in rather complex aspects of behavior we need to consider the possibility that persons can use these insights to manipulate tests in a way not intended by the designers of the tests. In the present case the subjects had no particular personal investment in the outcome of their test results; however if they wanted to be hired very badly to a certain job, or if they wanted to gain admission to a particular school or training program, they might find it easier than we would hope to attribute to themselves characteristics which they really did not possess but which they felt that the job required. However, incentives not to try hard to manipulate the self reports may prove to be adequate safeguards; for example, if one knows clearly that he will be expected to produce creatively if he scores high he may be less likely to overrate himself very much on creative ability.

Once again we may suggest the value of the BII as an instrument in predicting and understanding behavior. Since items in this instrument are empirically validated and often do not have obvious relevance to any particular task, it is probably very hard to detect the right alternative and so this type of test should be very hard to beat. Furthermore, such items probably are not especially subject to the influence of response set, since they cover such a wide variety subject matter. This fact should help make them reliable.

Generally speaking, there was positive support for the important idea that different psychological processes and traits are needed in learning existing knowledge in a typical school-like situations than are required in research participation situation where the central task is to produce new knowledge. At the present state of the art of measuring these processes and traits, the individual validities found were not yet as high as would be desired nor were the distinctions between the academic and research samples as sharp as might be hoped for. Nonetheless, the findings were generally positive and raise serious questions about the selection and education of scientists. If the task is to identify and develop those who will become the more productive and creative scientists, then the results in the study suggest that in both our selection and educational programs for science students we are at least somewhat off target. We are neither zeroed in on selecting the scientists with the highest potential nor giving them the most relevant and valid training in our usual education programs [illegible].

Table 1

Intercorrelations, Means, and Standard Deviations
of Criterion Scores for the NSF Academic Sample (N = 114)*

Criteria	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Means	SD
1. Overall Ranking by Peers	--															41.42	10.25
2. Overall Supervisor Ranking	64	--														42.70	13.94
3. Drive--Supervisory Rating	67	66	--													52.67	11.54
4. Cognition--"	65	59	89	--												53.30	10.30
5. Informative Ability--"	54	53	78	83	--											48.63	11.71
6. Flexibility--"	55	51	81	87	81	--										50.26	10.39
7. Persistance--"	61	60	86	78	68	70	--									53.35	10.14
8. Independence--"	64	56	84	91	82	87	74	--								49.77	9.98
9. Cooperation--"	49	48	71	69	79	73	65	72	--							50.72	10.05
10. Creative Ability--"	56	53	82	91	78	90	66	92	65	--						47.57	11.02
11. Quality of Work--"	66	66	75	67	58	57	73	64	53	60	--					50.41	9.16
12. Initiative--"	67	62	69	63	52	55	66	65	51	58	88	--				44.99	11.14
13. Originality"	65	58	63	64	54	53	56	62	41	61	81	86	--			47.49	9.38
14. Attitude Toward Work--"	57	60	63	53	46	48	65	55	43	51	87	89	85	--		54.91	10.28
15. Skill with People--"	37	45	44	35	45	34	38	38	59	33	63	67	61	68	--	49.20	10.93

Note: $r_{.05} = .19$; $r_{.01} = .25$ Decimal points in the correlations have been omitted in all of the tables

TABLE 2

Intercorrelations, Means, and Standard Deviations
Of Criterion Scores for the NSF Research-Participation Sample (N=172)

Criteria	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Means	SD
1. Ranking by Peers	--															41.61	9.82
2. Ranking by Supervisors	59	--														40.66	14.02
3. Drive--Superv. Rating	54	72	--													47.98	12.20
4. Cognition "	51	72	83	--												48.27	12.83
5. Informative Ability "	47	62	75	80	--											45.54	11.92
6. Flexibility "	48	73	79	78	80	--										46.12	12.39
7. Persistance "	47	76	83	78	74	82	--									48.94	14.29
8. Independence "	52	73	84	85	79	80	88	--								46.51	13.20
9. Cooperation "	38	65	65	66	73	71	73	67	--							47.12	12.46
10. Creative Ability "	56	77	82	88	80	79	81	86	65	--						44.29	13.23
11. Quality of Work "	49	65	64	64	61	70	70	67	69	67	--					47.72	11.81
12. Initiative "	48	70	71	68	66	74	72	76	62	71	79	--				43.41	12.80
13. Originality "	50	62	72	72	65	68	68	73	58	77	63	73	--			45.56	11.32
14.Attitude Toward Work "	51	64	72	65	61	68	72	67	57	69	73	70	69	--		52.44	11.24
15. Skill With People "	37	44	49	46	55	58	50	52	66	48	64	57	43	57	--	46.57	11.49

Note: $r_{.05} = .15$; $r_{.01} = .21$; decimal points omitted.

TABLE 3

Validity Coefficients for GPA Non Science, GPA Science and IQ for NSF Academic Sample

Predictor Academic Achievement	Criterion Number 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
GPA Non-Science	39	34	35	06	08	-13	36	04	-08	-10	43	34	26	37	04
GPA Science	36	34	27	09	16	-02	28	10	05	01	44	34	32	43	23
I. Q.	16	14	31	35	24	36	16	36	15	34	17	11	-03	-03	-14

Note: $r_{.05} = .25$; $r_{.01} = .33$

TABLE 4

Validity Coefficiences for GPA Non-Science, GPA Science, and IQ for the Research Participant Sample

Predictor	Criterion Number														
Academic Achievement	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
GPA Non-Science	14	30	36	46	32	39	37	41	36	34	40	37	26	34	22
GPA Science	13	30	33	47	30	38	35	34	32	32	38	33	25	32	25
I.Q.	-11	17	25	28	14	19	12	22	13	18	21	24	14	16	12

Note: $r_{.05} = .20$; $r_{.01} = .26$

TABLE 5

Comparisons between the Academic
Sample and the Research Sample on
GPA Science, GPA Non-Science and IQ

Variable	$\bar{X}_a$	SD_a	$\bar{X}_r$	SD_r	t
Grade-Point Average (non-science)	3.64	.36	3.42	.59	2.58 *
Grade-Point Average (science)	3.64	.35	3.53	.50	1.59
I.Q.	132.94	9.70	127.75	10.00	3.27 *

* significant at .01 level

TABLE 6

Validity Coefficients for the Aptitude Tests
In the NSF Academic Sample (N=114)

Predictor Aptitude Test	Criterion Number														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Pertinent Questions	18	14	25	25	29	30	17	27	23	29	20	17	18	10	08
Vocabulary	31	27	35	33	25	22	23	30	22	27	31	31	27	17	13
Plot Titles (Originality)	17	06	19	15	14	19	14	16	11	14	08	05	11	01	-01
Plot Titles (Fluency)	-14	07	-03	-03	00	03	-03	-09	06	-02	-01	02	00	02	12
Match Problems	28	25	21	27	16	19	14	26	14	29	08	25	26	17	03
Apparatus (Fluency)	01	-04	-02	02	-05	00	-06	-06	02	00	-05	-07	01	-16	-06
Apparatus (Originality)	17	19	18	15	20	11	16	14	12	14	10	05	02	06	09
Apparatus	09	07	07	11	06	07	03	01	06	07	09	03	07	-05	03
Compound Words	10	11	14	16	17	22	10	11	18	13	09	07	03	00	03
Gestalt Transformation	19	24	20	19	11	10	22	18	04	17	28	26	29	30	15
Brick Uses (Fluency)	-06	-03	-14	-14	-14	-13	-16	-15	-07	-13	-13	-08	-05	-13	-06
Brick Uses (Flexibility)	09	02	02	03	13	07	-03	13	07	03	00	-03	01	-06	-02
Revision II (Ideas)	20	16	32	27	26	25	29	28	33	24	41	29	22	30	34
Revision II (Words)	09	03	17	11	12	16	18	15	23	14	32	22	17	26	30
Revision II (Words/Ideas)	14	19	23	23	19	11	16	19	15	13	10	10	05	04	04
Visual Imagery	31	18	22	31	14	25	18	29	15	32	13	28	27	14	05
Planning Elaboration	15	10	11	12	09	07	03	13	18	10	07	09	10	01	07
Meaningful Statements	00	02	06	08	12	08	-06	04	06	07	04	-01	-01	-10	-04

Note: $r_{.05} = .19$; $r_{.01} = .25$.

TABLE 7

Validity Coefficients for the Aptitude Tests in the Research Participation Sample (N=172)

Predictor Aptitude test	Criterion Number 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Pertinent Questions	00	-03	12	04	00	08	11	05	08	10	05	06	12	03	06
Vocabulary	10	18	25	34	23	25	20	27	19	30	27	27	27	28	12
Plot Titles (Originality)	08	17	10	12	14	14	07	06	14	13	13	15	12	-02	08
Plot Titles (Fluency)	-04	12	-01	-06	-03	-03	04	06	-04	02	00	02	04	02	-05
Match Problems	00	06	06	12	05	07	03	06	-02	10	06	02	07	01	00
Apparatus (Fluency)	05	05	03	02	-03	03	-02	02	-03	05	-03	-01	-02	-02	-07
Apparatus (Originality)	01	05	04	05	-07	05	02	06	-02	08	05	04	-01	-01	-07
Apparatus	-13	-20	-05	-06	-11	-07	-06	-05	-05	-08	-07	00	-04	-06	-07
Compound Words	02	08	05	10	09	00	04	11	06	11	05	07	09	05	06
Gestalt Transformation	13	03	14	19	09	13	07	16	03	19	18	10	16	13	13
Brick Uses (Fluency)	-02	02	-02	-03	-01	-04	-03	02	-09	06	-03	-01	02	-05	01
Brick Uses (Flexibility)	04	19	03	08	01	-01	05	06	-03	15	03	01	05	-04	00
Revision II (Ideas)	-04	03	-03	-04	00	-04	-01	-01	04	-01	01	-03	04	-03	-02
Revision II (Words)	-06	00	-09	-12	-06	-11	-08	-11	-03	-09	-05	-09	02	-07	-09
Revision II (Words/Ideas)	-03	00	-07	-10	-09	-11	-09	-14	-09	-11	-07	-09	-02	-04	-11
Visual Imagery	07	12	13	25	12	18	08	15	09	13	17	16	15	12	05
Planning Elaboration	13	06	07	00	-04	-01	00	06	-01	07	04	04	07	03	06
Meaningful Statements	11	07	16	10	06	09	07	13	04	15	11	11	06	12	12

Note: $r_{.05} = .15$; $r_{.01} = .21$

TABLE 9

Validity Coefficients for the Satisfactory Achievement
Scale in the NSF Academic Sample

Predictor Aspiration Scale	Criterion Number 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Reading Ability	34	16	40	39	23	29	34	29	19	31	33	27	24	19	-01
Writing Ability	28	14	33	35	28	31	28	30	20	31	32	28	24	21	12
Quantity of Work	07	04	12	16	12	15	06	10	10	18	03	03	02	-05	-05
Administrative Ability	-10	-11	-13	-15	-16	-18	-10	-17	-07	-16	-16	-09	-17	-07	07
Being Well Liked	-04	-01	-05	-05	06	-13	-06	-04	15	-06	-06	-04	-13	-11	17
Speaking Ability	08	02	20	19	25	21	10	12	21	20	17	09	12	09	17
Listening Ability	21	05	28	34	32	31	25	28	15	32	16	13	17	10	-04
Being Well Known	06	00	-04	-03	01	-05	03	-09	-06	-05	05	-06	-06	-06	01
Theoretical Contributions	15	20	11	12	04	01	09	09	-05	09	13	17	24	22	01
Experimental Contributions	09	05	05	02	-02	00	-01	02	00	06	-02	-01	04	04	-01
Actual Practice	-15	-09	04	11	01	09	11	04	05	08	-02	-17	-11	-18	-19
Quantity of Published Reports	13	06	03	11	02	00	02	-02	-08	02	07	-01	07	05	-05
Level of Original Work	32	32	28	27	10	20	21	18	15	27	21	23	24	22	-07

Note: $r_{.05} = .19$; $r_{.01} = .25$.

TABLE 8

Comparisons between the Academic Sample and the Research Participation Sample on the 23 Aptitude Test Scores

	Academic N=114		Research N=172		
Test	$\bar{X}_a$	SD_a	$\bar{X}_r$	SD_r	t
Pertinent Questions	12.14	2.54	12.18	2.39	.14
Vocabulary	31.51	3.95	30.94	4.63	1.09
Plot Titles (Fluency)	1.75	1.77	1.34	1.70	1.95
Plot Titles (Originality)	10.18	4.80	10.26	4.49	.13
Match Prob. (correct)	7.92	3.26	7.40	3.27	1.33
Apparatus	12.75	3.83	12.74	3.83	.00
Apparatus	26.00	9.23	27.24	9.27	1.11
Apparatus	20.81	5.78	21.85	4.88	.17
Compound Words	13.19	6.86	11.91	6.57	1.59
Gestalt Trans.	12.46	2.95	12.24	2.73	.62
Brick Uses (Fluency)	18.70	5.72	18.44	5.84	.38
Brick Uses (Flexibility)	9.40	4.15	10.17	4.66	1.43
Revision II (Ideas)	17.41	3.02	16.82	3.16	1.58
Revision II (Words)	35.55	7.07	34.41	6.84	1.35
Revision II Words/Idea	20.56	2.64	20.59	2.76	.01
Visual Imagery score	16.15	3.65	16.35	3.84	.44
Planning Elaboration	12.31	3.88	11.65	3.66	1.46
Meaningful Statements	58.61	17.95	52.62	17.88	2.79*

* Significant at the .01 level

TABLE 10

Validity Coefficients of the Satisfactory Achievement Scale in Research Participation Sample

Predictor Aspiration Scale	Criterion Number														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Reading Ability	09	-06	07	06	08	07	-02	-01	13	01	14	04	05	05	07
Writing Ability	06	-02	07	09	12	15	02	-01	15	06	10	04	06	04	07
Quantity of Work	-03	-03	05	06	14	08	03	04	11	-01	-07	-06	-07	03	07
Administrative Ability	00	03	-18	-15	-04	-07	-08	-13	03	-16	-05	-12	-19	-08	-07
Being Well Liked	-04	-17	-11	-12	02	04	-06	-05	03	-10	06	03	-10	-16	07
Speaking Ability	17	14	12	21	29	21	16	19	26	19	15	18	14	11	11
Listening Ability	21	07	11	10	11	07	06	07	12	03	04	-01	06	02	03
Being Well Known	-09	-06	-07	-11	-06	-08	-07	-04	-05	-12	-10	-04	-06	-12	-09
Theoretical Contributions	15	15	21	21	12	12	19	15	06	15	08	13	16	12	04
Experimental Contributions	20	16	21	21	13	16	19	16	08	17	12	11	16	12	13
Actual Practice	-01	-17	-13	-15	-03	-11	-05	-11	07	-07	-09	-04	-08	-12	06
Quantity of Published Reports	18	16	30	28	23	22	28	21	15	22	14	19	23	27	08
Level of Original Work	16	13	25	25	20	15	21	16	13	22	09	11	18	17	04

Note: $r_{.05} = .15$; $r_{.01} = .21$

TABLE 11

Comparisons Between the Academic Sample and the Research Sample on the 13 Satisfactory Achievement Scales

Aspiration Scale	$\bar{X}_a$	SD_a	$\bar{X}_r$	SD_r	t
Reading Ability	48.77	8.39	48.12	9.03	.61
Writing Ability	44.30	9.46	43.55	10.63	.61
Quantity of Work	48.51	8.81	47.56	8.58	.90
Administrative Ability	39.74	12.24	37.27	12.24	1.67
Being Well Liked	44.65	10.02	43.90	10.40	.60
Speaking Ability	46.73	8.36	47.04	9.42	.28
Listening Ability	48.51	7.64	48.89	8.22	.39
Being Well Known	42.19	10.66	42.04	10.97	.11
Theoretical Contributions	31.32	11.36	33.37	10.44	1.56
Experimental Contributions	33.68	10.37	34.83	9.82	.94
Actual Practice	35.53	12.36	35.12	12.31	.28
Quan. of Pub. Reports	22.63	10.09	25.06	10.17	1.98*
Level of Original Work	33.60	12.50	35.93	10.53	1.70

* Significant at the .05 level.

TABLE 12

Validity Coefficients for the BII in the NSF Academic Sample (N=114)

Predictor	Criterion Number														
Biographical Keys	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
General Intellectuality	27	12	13	18	11	06	06	15	01	15	19	11	23	07	-02
Independence	12	01	07	13	07	14	06	15	02	15	08	05	19	10	-09
Professional Self Confidence	10	04	-02	02	02	-05	-07	02	-04	02	-05	00	08	-04	-01
Miscellaneous	26	15	21	24	17	17	22	23	15	20	16	07	12	09	-02
Form A Total Creativity	30	11	15	23	14	11	08	21	04	20	16	10	27	09	-05
Extent of Exper. & Parti.	15	04	03	05	-05	-03	-01	02	-06	06	02	07	18	07	-04
Form B Total Creativity	32	13	17	21	18	19	07	27	08	25	13	13	24	06	00

Note: $r_{.05} = .19$; $r_{.01} = .25$; decimal points omitted

TABLE 13

Validity Coefficients for the BII in the NSF Research Participation Sample (N=172)

Predictor							Criterion Number								
Biographical Keys	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
General Intellectuality	14	13	32	38	26	24	20	26	12	33	22	18	29	29	07
Independence	14	16	28	27	24	19	18	21	13	25	17	20	28	21	08
Professional Self Confidence	16	14	24	31	24	18	16	20	06	22	12	16	31	13	07
Miscellaneous	03	09	06	07	-02	06	02	07	08	06	07	-02	03	03	-01
Form A. Total Creativity	19	20	36	43	30	28	23	30	14	36	24	22	36	28	08
Extent of Exper. & Parti.	22	-03	11	13	02	07	02	08	-09	17	-01	03	12	01	-03
Form B Total Creativity	19	15	33	36	30	22	20	24	15	25	21	19	28	24	07

Note: $r_{.05} = .15$; $r_{.01} = .21$; decimal points omitted.

TABLE 14

Comparisons Between the NSF Academic Sample (a)
And the NSF Research Participation Sample (r) on the Seven BII Keys

Biographical Keys	$\bar{X}_a$	SD_a	$\bar{X}_r$	SD_r	t
General Intellectuality	56.66	4.32	56.23	4.45	.81
Independence	50.56	2.86	51.02	3.21	1.25
Professional Self Confidence	51.23	2.39	51.41	2.32	.65
Miscellaneous	50.71	1.72	50.29	1.62	2.11*
Total Creativity (Form A)	59.11	7.29	58.87	8.06	.26
Extent of Exper. & Partic.	43.62	9.94	46.31	10.89	2.10*
Total Creativity (Form A)	54.59	5.23	54.54	5.34	.08

* Significant at the .05 level.

TABLE 15

Validity Coefficients for the Self Description
Scale in the Academic Sample

Predictors Self Rating	Criterion Numbers 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Drive	28	26	26	23	28	23	19	25	25	17	26	17	05	08	11
Math Ability	09	-02	11	20	14	13	03	17	01	22	06	14	21	06	12
Cognitive Ability	21	02	26	31	26	28	13	30	17	30	17	13	14	-01	04
Integrity	22	14	36	34	33	35	29	36	37	34	25	20	13	14	14
Informative Ability	09	03	14	16	13	20	05	14	14	12	07	13	12	01	16
Quality of Skill in Design	16	01	12	16	04	13	09	14	04	16	00	03	16	-03	-04
Flexibility	07	-21	16	19	19	24	09	19	19	20	02	05	05	-06	03
Persistance	11	13	21	16	16	15	20	13	19	11	-15	09	02	08	16
Independence	21	06	16	19	15	16	06	20	08	21	-09	-10	10	-01	-04
Discrimination of Value	13	-01	14	08	13	09	09	07	07	09	-13	07	10	-02	04
Resourcefulness	09	-02	10	11	17	20	04	15	11	15	01	-01	00	-06	-06
Desire for Facts	12	07	17	17	12	03	14	15	16	14	18	11	08	08	-04
Desire for Principles	30	17	29	31	28	22	23	32	25	29	25	21	23	14	07
Desire for Discovery	14	08	08	09	05	03	04	05	07	09	10	06	06	03	02
Cooperation	01	-01	08	07	15	13	07	06	24	05	08	05	-01	01	25
Intuition	09	00	08	09	07	07	-02	12	06	13	02	01	05	-05	-05
Creative Ability	13	-10	08	12	11	03	04	13	05	13	01	03	10	-01	03

Note: $r_{.05} = .19$; $r_{.01} = .25$. Decimal points omitted

TABLE 16

Validity Coefficients for the Self Description Scale in the Research Participation Sample

Predictor Self Rating	Criterion Number 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Drive	32	21	29	28	26	20	18	22	15	27	21	19	26	22	17
Math Ability	25	26	23	26	14	19	18	21	04	22	18	11	20	15	04
Cognitive Ability	28	18	20	27	21	18	14	21	07	26	17	17	21	16	10
Integrity	25	11	13	14	13	18	11	12	01	15	05	02	09	08	-03
Informative Ability	20	11	10	12	13	14	04	05	10	12	10	06	04	-02	01
Quality of Skill in Design	16	14	00	06	01	05	-05	00	-07	04	02	02	07	-01	-02
Flexibility	11	16	07	14	07	09	07	03	-05	11	03	00	09	09	-11
Persistence	23	30	21	24	20	19	20	20	10	20	15	12	20	21	05
Independence	31	31	30	31	33	25	25	27	14	28	21	20	25	26	18
Discrimination of Value	18	19	15	18	14	17	12	09	10	14	14	10	23	16	08
Resourcefulness	31	13	13	17	13	10	11	10	-01	16	05	01	13	10	-03
Desire for Facts	14	13	28	22	19	14	15	13	10	26	11	04	17	24	06
Desire for Principles	30	23	24	22	12	19	16	15	05	24	12	07	17	19	04
Desire for Discovery	33	13	25	25	16	17	13	15	04	22	09	13	21	18	01
Cooperation	-03	-06	-04	00	05	07	02	04	-02	00	-07	-05	-09	-16	-03
Intuition	08	08	02	11	06	09	04	02	-07	09	04	04	01	03	-04
Creative Ability	21	08	09	17	08	12	09	05	-04	19	01	00	11	10	-03

Note: $r_{.05} = .15$; $r_{.01} = .21$. Decimal points omitted.

TABLE 17

Comparisons Between the NSF Academic Sample and the NSF Research Participation Sample on the Self Description Scale

Self Rating	$\bar{X}_a$	SD_a	$\bar{X}_r$	SD_r	t
Drive	51.32	11.12	51.51	10.26	.15
Math Ability	47.98	12.51	47.33	12.93	.42
Cognitive Ability	52.46	10.48	51.51	10.87	.73
Integrity	51.93	11.54	51.51	10.71	.31
Informative Ability	48.16	12.67	48.95	12.24	.52
Design Skill	40.09	13.60	41.34	12.19	.81
Flexibility	50.26	12.39	51.51	10.98	.89
Persistance	49.56	11.58	50.40	12.16	.58
Independence	48.07	10.59	49.24	10.98	.89
Discrimination of Value	49.47	11.91	49.36	10.98	.08
Resourcefulness	48.42	10.73	47.62	10.90	.61
Desire for Facts	53.53	11.13	52.91	12.08	.44
Desire for Principles	53.16	12.16	51.92	11.91	.82
Desire for Discovery	49.12	11.59	50.17	10.79	.78
Cooperation	48.77	12.08	48.07	12.71	.46
Intuition	47.72	14.21	47.91	12.10	.12
Creative Ability	43.16	11.80	45.61	11.17	1.80

There are no significant differences between the two groups

TABLE 18

Validity Coefficients for the NMSC
Form for Academic Sample

Predictor NMSC Form	Criterion Number 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
NMSC No. of Creative Activities	05	02	-03	03	03	-02	-13	-04	01	01	-03	-08	01	-08	-07
Daydream (Work Activities)	-12	-13	-06	-12	04	-01	-01	-05	02	-08	-18	-16	-22	-15	-12
Daydream (Outstanding Accomp)	29	23	07	14	05	06	03	09	00	11	16	15	20	19	14
Daydream (Helping others)	-08	-06	-05	-02	-03	-03	-01	01	-04	-03	03	-02	01	-05	-05
Occupational Choice (Science)	06	12	07	06	13	14	00	10	10	13	14	13	16	11	12
Number of School Activities	-04	04	02	00	-02	-08	-03	-08	04	-07	-01	-03	-03	-02	05
NMSC Self Evaluation	07	04	10	02	12	06	01	01	15	-01	09	03	-08	-05	17
Emotional Stability	03	-07	12	06	16	15	00	08	28	07	06	12	01	07	26
Originality	25	11	17	17	11	13	09	16	04	16	14	09	15	04	01
Leadership	-02	03	04	-04	09	03	-05	-03	15	-03	06	07	-09	00	24
Athletic Ability	00	07	03	-01	06	04	-07	06	17	02	01	08	00	-02	30
Drive to achieve	10	09	14	10	18	11	12	06	20	05	13	01	-03	01	12
Scholarship	19	22	30	22	23	12	18	20	15	16	26	17	10	14	13
Independence	-05	-10	-07	-10	-02	-06	-11	-09	06	-11	-07	-06	-11	-13	08
Self Control	-03	05	03	-08	00	-07	02	-05	03	-07	02	05	-01	01	17
Conservatism	-03	-01	02	-10	-03	-09	00	-11	-05	12	02	00	-13	-02	12
Self Understanding	12	07	18	15	22	18	08	17	23	15	17	09	04	07	24
Leadership activities	-10	-05	-17	-16	-03	-13	-20	-17	-06	-15	-15	-22	-22	-23	-09
Art Activities	04	12	02	02	05	01	-03	-01	-01	01	-02	-09	-03	-10	-05
Science Activities	07	06	-10	-03	-03	-11	-06	-09	-05	-08	-04	-03	04	-02	-10
Topic Selected (Science)	11	11	05	11	03	10	03	07	-07	10	00	06	12	05	-05
Topic Selected (Education)	05	01	06	00	02	-01	06	06	10	02	13	07	00	05	08
Topic Selected (Politics)	-16	-08	-12	-04	00	-02	-08	-08	-03	-05	-13	-12	-12	-09	-05
Total Number of Words	18	00	06	08	14	07	01	09	16	06	05	08	12	07	15
Originality	21	07	13	18	22	19	06	23	21	19	18	17	22	18	18

Note: $r_{.05} = .19$; $r_{.01} = .25$. Decimal points omitted.

TABLE 19

Validity Coefficients for the NMSC
Form for Research Sample

Predictor NMSC Form	Criterion Number 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
NMSC No. of creative activities	10	01	04	00	-01	-04	-07	-01	-10	00	-06	-10	01	-01	02
Daydream (Work activities)	-24	-11	-20	-18	-17	-23	-12	-13	-17	-17	-11	-13	-14	-18	-16
Daydream (Outstanding accom)	22	23	17	13	08	10	11	08	02	14	09	03	03	11	03
Daydream (Helping others)	-10	-08	-02	-04	-05	-07	-04	00	04	-03	-04	-02	-01	-05	03
Occupational Choice (science)	20	03	22	15	09	12	11	17	05	10	10	12	06	08	07
No. of School activities	07	02	-02	04	-05	01	-06	00	-08	05	-11	-01	10	05	02
NMSC Self Evaluation	16	-05	13	16	19	10	11	14	10	09	05	06	11	-01	08
Emotional Stability	05	-09	05	06	11	10	00	02	12	03	09	05	03	-01	12
Originality	14	20	18	17	15	10	08	12	09	18	09	09	22	13	09
Leadership	00	-16	-02	01	06	01	-04	-01	02	-02	-06	02	05	-08	05
Athletic Ability	09	-06	-07	01	-01	-03	-09	-03	-08	-04	-07	00	01	-04	00
Drive to Achieve	23	12	27	27	29	20	19	26	19	19	17	11	19	18	15
Scholarship	08	15	23	30	20	17	18	23	17	19	26	17	22	18	10
Independence	04	-05	10	10	11	08	00	03	-04	07	-06	01	10	01	-03
Self Control	12	01	08	12	01	07	06	07	07	07	11	06	09	04	08
Conservatism	12	03	-09	-06	01	-01	-07	-04	04	-08	-04	-06	-08	-09	11
Self Understanding	-04	03	09	08	09	12	05	01	02	08	07	07	10	04	03
Leadership Activities	11	03	05	12	12	07	02	10	-04	14	-03	06	18	01	04
Art Activities	07	04	-03	10	06	-02	-08	-02	-06	10	-05	-04	13	-02	00
Science Activities	28	15	23	29	14	17	15	23	-01	29	18	21	28	21	10
Topic Selected (Science)	16	08	07	03	03	03	04	04	-03	05	01	07	05	03	10
Topic Selected (Education)	-02	-01	-08	-03	-01	-03	-04	-06	-02	-07	-03	-04	-13	-04	-14
Topic Selected (Politics)	-13	-20	-02	-02	-04	-02	-05	-02	-03	-02	-06	-07	10	-04	02
Total Number of words	-08	-03	-04	-09	-11	-06	-13	-15	-10	-04	-06	-07	-06	-12	-02
Originality	09	12	06	05	02	02	-05	00	03	10	14	13	07	05	07

Note: $r_{.05}$ = .15; $r'_{.01}$ = .21. Decimal points omitted.

TABLE 20

Comparisons Between Academic Sample and Research Sample on the NMSC Form

Test	$\bar{X}_r$	SD_r	$\bar{X}_a$	SD_a	t
Number of Creative Activities	12.27	4.37	12.26	4.55	.002
Daydream (Work Activ.)	.27	.48	.18	.41	.016
Daydream (Creat. Acc.)	.39	.52	.35	.48	.063
Daydream (Help Others)	.14	.35	.11	.31	.067
Occup. Choice (Science)	.75	.44	.68	.46	.127
No. of School Activities	20.51	6.68	19.90	5.92	.787
Self Evaluation	9.01	5.17	9.07	5.45	.094
Emotional Stability	35.81	11.13	32.48	12.01	2.390*
Originality	33.49	10.68	33.10	9.60	.313
Leadership	30.51	7.80	31.58	8.99	1.070
Athletic Ability	25.00	11.62	24.60	11.90	.283
Drive to Achieve	36.90	8.18	37.76	8.30	.863
Scholarship	39.42	10.01	42.92	7.95	3.119**
Independence	32.50	8.38	32.48	9.05	.002
Self Control	34.27	11.27	32.83	11.93	1.029
Conservatism	29.33	9.13	29.82	8.95	.445
Self Understanding	33.22	11.46	32.57	11.43	.468
Leadership Activities	5.33	3.44	4.48	3.12	2.114*
Art Activities	3.39	3.33	3.18	2.93	.172
Science Activities	3.42	2.88	2.55	2.54	.825
Topic (Science)	.29	.47	.26	.44	.545
Topic (Education)	.45	.50	.55	.50	1.587
Topic (Politics)	.19	.39	.12	.33	1.556
Total No. of Words	11.15	6.40	9.63	6.30	1.964
Originality of Essay	29.77	10.11	28.69	10.33	.348

* Significant at the .05 level. **Significant at the .01 level

TABLE 21

Intercorrelations of Control Scores with the Criteria
for the Academic Sample

	Criterion Scores														
Control Score	1	2-	3	4	5	6	7	8	9	10	11	12	13	14	15
Father's Educational Level	06	04	18	21	11	14	07	14	05	16	15	05	07	02	00
Age	03	-04	-26	-33	-25	-32	-17	-19	-13	-28	-16	-01	-03	-01	07
Sex	14	-03	-02	05	00	-03	-07	06	-11	09	03	09	22	09	02
Grade Level	02	-04	-22	-30	-19	-27	-16	-19	-11	-26	-10	03	-02	-01	14
Number of Science Courses	09	-05	-21	-16	-11	-25	-13	-20	-14	-19	-13	-02	07	-04	-02

Note: $r_{.05} = .19$; $r_{.01} = .25$; decimal points omitted.

TABLE 22

Intercorrelations of Control scores with the Criteria
for the Research Sample

	Criterion Scores														
Control Score	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Father's Educational Level	-10	-10	-06	01	-01	05	-13	-10	02	-08	-04	-08	-09	-08	-05
Age	17	-05	-06	-16	-10	-05	-10	-09	-06	-12	03	-08	-18	-03	13
Sex	08	-01	07	09	02	10	13	08	04	10	05	09	10	03	-03
Grade Level	24	11	08	02	-01	09	06	12	06	03	18	10	-02	14	20
Number of Science Courses	16	-02	15	08	-06	12	09	07	01	00	11	08	01	18	17

Note: $r_{.05} = .15$; $r_{.01} = .21$. Decimal points omitted.

TABLE 24

Comparisons between the NSF Research Participation Sample (r) And the Local Sample (1) on the Aptitude Test Scores

Test	X_r	SD_r	X_1	SD_1	t
Pertinent Questions	12.18	2.39	11.832	2.867	.544
Vocabulary	30.94	4.63	22.782	6.931	9.21*
Plot Titles (fluency)	1.34	1.70	1.703	1.803	1.64
Plot Titles(Originality)	10.26	4.49	11.881	5.021	2.67*
Match Problem (No. right)	7.40	3.27	5.634	2.704	4.82*
Apparatus (Fluency)	12.74	3.83	12.772	4.591	.055
Apparatus (Originality)	27.24	9.27	28.257	10.795	.789
Apparatus (Originality per item)	21.85	4.88	21.851	4.629	.0016
Compound Words	11.91	6.57	12.475	5.939	.733
Gestalt Transformations	12.24	2.73	9.178	2.889	8.59*
Brick Uses (Fluency)	18.44	5.84	19.782	6.999	1.617
Brick Uses (Flexibility)	10.17	4.66	7.783	4.625	4.09*
Revision II (Ideas)	16.82	3.16	15.960	3.819	1.90
Revision II (Words)	34.41	6.84	35.900	8.543	1.00
Revision II (Ideas/ words)	20.59	2.76	2.307	.487	4.68*
Visual Imagery (No. right)	16.35	3.84	12.287	3.716	8.58*
Planning elaboration	11.65	3.66	11.950	4.531	.564
Meaningful Statements	52.62	17.88	44.149	19.774	3.53*

* Significant at .05 level

TABLE 25

Comparisons between the NSF Academic Sample (a) and the Local Sample (1) on the seven BII Keys

Biographical Keys	$\bar{X}_a$	SD_a	$\bar{X}_1$	SD_1	t
General Intellectuality	56.66	4.32	50.67	3.93	10.68*
Independence	50.56	2.86	48.76	2.97	4.50*
Professional Self Confidence	51.23	2.39	49.79	2.43	4.36*
Miscellaneous	50.71	1.72	49.63	1.84	4.50*
Total Creativity (Form A)	59.11	7.29	48.96	7.57	9.06*
Extent of Exper. & Parti.	43.62	9.94	37.98	9.60	4.24*
Total Creativity (Form B)	54.59	5.23	48.86	5.30	7.96*

* Significant at the .01 level.

TABLE 26

Comparisons Between the NSF Research Participation Sample (r) and the Local Sample (l) on the seven BII Keys

Biographical Keys	$\bar{X}_r$	SD_r	$\bar{X}_l$	SD_l	t
General Intellectuality	56.23	4.45	50.67	3.93	10.28*
Independence	51.02	3.21	48.76	2.97	5.79*
Professional Self Confidence	51.41	2.32	49.79	2.97	5.40*
Miscellaneous	50.29	1.62	49.63	1.84	3.10*
Total Creativity (Form A)	58.87	8.06	48.96	7.57	10.01*
Extent of Exper. & Parti.	46.31	10.89	37.98	9.60	6.51*
Total Creativity (Form B)	54.45	5.34	48.86	5.30	8.46*

* Significant at the .01 level.

TABLE 27

Comparisons Air Force, NSF Research Participation And NSF Academic Samples on the Satisfactory Achievement Scale

SAS Scale	Air Force*	NSF Res.+	NSF Acad.+
Quantity of Written Reports	7	13	0
Theoretical Contributions	7	9	3
Level of Original Work	7	13	11
Being Well Liked	4	-2	0
Writing Skills	4	-2	13
Quantity of Work	4	0	0
Being Well Known	3	0	0
Reading Skills	3	0	13

* Seventeen factored criteria were used in this study.
+ Fifteen non-factored criteria were used in this study.

TABLE 28

Comparisons Between the Air Force, NSF Research Participation And NSF Academic Samples on the Self Description Scale

SD Scale	Air Force *	NSF Res.+	NSF Acad.+
Creative Ability	12	3	0
Discrimination of Value	11	10	0
Cognitive Ability	9	13	7
Desire for Principles	9	9	12
Drive	8	15	10
Flexibility	7	2	7
Independence	7	15	4
Intuition	7	0	0
Desire for Discovery	6	9	0
Resourcefulness	5	3	1
Math Ability	4	12	3
Informative Ability	4	2	1

*Seventeen factored criteria were used in this study
+ Fifteen non-factored criteria were used in this study

TABLE 29

COMPARISON OF ACADEMIC AND RESEARCH PARTICIPATION SAMPLES SHOWING NUMBER OF CRITERION SCORES WITH WHICH EACH PREDICTOR WAS SIGNIFICANTLY CORRELATED

Name of Test	Academic	Research
School Scores		
I.Q.	5	5
Past academic achievement (science)	8	14
Past academic achievement (non-science)	8	14
Aptitude tests		
Revision II (ideas)	14	0
Match problems	9	0
Pertientn questions	8	0
Gestalt transformation	9	4
Revision II (words)	5	0
Revision II (words/ideas)	5	0
Apparatus (originality)	2	0
Compound words	1	0
Vocabulary	13	13
Visual Imagery	8	6
Plot Titles (orig.)	2	2
Plot Titles (fluency)	0	0
Planning, Elaboration	0	0
Brick Uses (fluency)	0	0
Apparatus (fluency)	0	0
Apparatus	0	-1
Meaningful statements	0	2
Brick Uses (flexibility)	0	2
Satisfactory Achievement Scale		
Reading ability	13	0
Writing ability	13	2
Listening ability	8	1
Level of original work	11	10
Speaking ability	6	10
Actual practice	-1	-2
Being well known	0	0
Quantity of work	0	0
Being well liked	0	-2
Administrative ability	0	-4
Theoretical contributions	3	8
Experimental contributions	0	9
Quantity of published reports	0	13

Name of Test	Academic	Research
Self Description		
Integrity	11	3
Flexibility	-1; 6	1
Cooperation	2	-1
Informative ability	1	1
Intuition	0	0
Desire for principles	12	10
Drive	10	15
Quality of skill in design	0	1
Resourcefulness	1	3
Creative ability	0	3
Discrimination of values	0	7
Desire for facts	0	7
Desire for discovery	0	9
Math ability	3	11
Persistence	3	12
Cognitive ability	7	12
Independence	4	14
Biographical Information Inventory		
Miscellaneous	6	0
Extent of experience and participation	0	2
Professional Self-confidence	0	10
Intellectuality	3	11
Independence	1	12
Total creativity (Form A)	5	13
Total Creativity (Form B)	6	14
National Merit Scholarship Corporation		
Originality	7	0
Leadership activities	-4	1
Daydream (high and creative accomplishment)	3	0
Self Understanding	2	0
Emotional stability	1	0
Athletic ability	0	0
Topica selected (Education)	0	0
Art activities	0	0
NMSC # of creative activities	0	0
Daydrea, (helping others)	0	0
Independence	0	0
Self control	0	0
Conservatism	4	3
Leadership		
Topic selected (science)	1	-1
Topics selected (politics)	0	-1
Total no. of words	0	-1
NMSC self-evaluation	0	3
Number of school activities	0	4
Occupational choice (science)	0	4
Originality	1	5
Daydream (work activities)	-1	-9
Scholarship	7	13
Drive to achieve	1	13

TABLE 30

Validity Coefficients Between 83 Predictors and 1
Criterion of Overall Supervisor Ranking

Number valid for academic sample (but not for research sample)		Number valid for research sample (but not for academic sample)		Number valid for both samples: Academic		Number valid for both samples: Research	
.30 - .39	1	.30 - .39	2	.30 - .39	2	.30 - .39	2
.20 - .29	2	.20 - .29	5	.20 - .29	6	.20 - .29	2
.19	2	.15 - .19	14	.19		.15 - .19	4
Total Signif.	5	Total Signif.	21	TOTAL	8	TOTAL	8
not signif.	70	not signif.	54				

TABLE 31

Validity Coefficients Between 83 Predictors and 1
Criterion Rating on Creativity

Number valid for Academic Sample (but not for research sample)		Number valid for Research sample (but not for academic sample)		Number valid for both samples Academic		Research	
.30 - .39	4	.30 - .39	3	.30 - .39	3	.30 - .39	2
.20 - .29	5	.20 - .29	8	.20 - .29	8	.20 - .29	6
.19	1	.15 - .19	13	.19		.15 - .19	3
Total Signif.	10	Total signif.	24	TOTAL	11	TOTAL	11
not signif.	62	not signif	48				

BIBLIOGRAPHY

Chorness, M. H., and D. H. Nottelmann. The prediction of creativity among Air Force civilian employees. Res. Bull., AFPTRC -TN-57-36. Lackland Air Force Base, Texas: Air Force Personnel and Training Research Center, March 1957.

Ellison, R. L. The relationship of certain biographical information to success in science. Unpublished Masters' thesis. Univer. of Utah, 1960.

Ellison, R. L. The relationship of certain biographical information to success in science. Paper read at Western Psychol. Ass., San Francisco, April, 1962.

Getzels, J. W. & Jackson, P. W. The highly intelligent and the highly creative adolescent: a summary of some research findings. In C. W. Taylor (Ed), *The Third (1959) Research Conference on the Identification of Creative Scientific Talent*. Salt Lake City: Univer. of Utah Press, 1959.

Guilford, J. P. Three faces of intellect. *Amer. Psychologist*, 1959, *14*, 469-479.

Holland, J. L. Creative and academic performance among talented adolescents. *J. Educ. Psychol.*, 1961, *52*, 136-147.

Jablonski, J. In C. W. Taylor (Ed.) *The Fifth (1962) Research Conference on the Identification of Creative Scientific Talent*. Salt Lake City in press.

MacKinnon, D. W. The creativity of architects. Paper presented at *The Fifth Research Conference on the Identification of Creative Scientific Talent*, Salt Lake City, in press.

MacKinnon, D. W. The nature and nurture of creative talent. *Amer. Psychol.*, 1962, *17*, No. 7.

Martin, R. A. & Pachares, J. Good scholars not always best. *Business Week*, February 24, 1962, 77-78.

Mullins, C. J. The prediction of creativity in a sample of research scientists In G. Finch (Ed.) *Symposium on Air Force human engineering, personnel, and training research.* Washington: National Academy of Sciences--National Research Council, Publication 783, 1960, 144-161.

Riley, R. F. and C. G. Overberger. A Summer Research Participation Program for High School Students, Polytechnic Institute of Booklyn. *J. chem. Educ.*, Vol. 38, August 1961, p. 424.

Roe, Anne. A psychological study of eminent biologist. *Psychol. Monogr.*, 1951, *65*, No. 14.

Roe, Anne. A psychological study of physical scientists. Genet. psychol. Monogr., 1951, 43, 121-239.

Smith, W. J., Albright, L. E., Glennon, J. R., & Owens, W. A. The prediction of research competence and creativity from personal history. J. appl. Psychol., 1961, 45, 59-62.

Sprecher, T. B. An investigation of criteria for creativity in engineers. Unpublished doctoral dissertation, Univer. of Maryland, 1957.

Taylor, C. W. (Ed.) The First (1955) Research Conference on the Identification of Creative Scientific Talent. Salt Lake City: Univer. of Utah Press, 1956.

Taylor, C. W. (Ed.) The Second (1957) Research Conference on the Identification of Creative Scientific Talent. Salt Lake City, Univer. of Utah Press, 1958.

Taylor, C. W. (Ed.). The Third (1959) Research Conference on the Identification of Creative and Scientific Talent. Salt Lake City: Univer. of Utah Press, 1959.

Taylor, C. W. (Ed.). The Fifth Research Conference on the Identification of Creative Scientific Talent. Salt Lake City, in press.

Taylor, C. W., and Barron, F. Scientific Creativity: Its Recognition and Development. Wiley and Sons, New York, 1963.

Taylor, C. W., & Ellison, R.L. Summary of biographical results for the prediction of success in science. Paper presented at the fifth research conference on the identification of creative scientific talent. Salt Lake City, in press.

Taylor, C. W., Smith, W. R., Ghiselin, B., & Ellison, R. Explorations in the measurement and prediction of contributions of one sample of scientists. Report ASD-TR-61-96, Aeronautical Systems Division , Personnel Laboratory Lackland Air Force Base, Texas, April 1961.

Taylor, D. W. Variables related to creativity and productivity among men in two research laboratories. In C. W. Taylor, (Ed.), The Second (1957) Research Conference on the Identification of Creative Scientific Talent. Salt Lake City: Univer. of Utah Press, 1958.

Torrance, E. P. Explorations in creative thinking in the early school years: A progress report. In C. W. Taylor, (Ed.), The Third (1959) Research Conference on the Identification of Creative Scientific Talent. Salt Lake City: University of Utah Press, 1959.

Torrance, E. P. Educational achievement of the highly intelligent and the highly creative: Eight partial replications of the Getzels--Jackson study. Research Memorandum BER-60-18, Minneapolis: Bureau of Educational Research, Univer. of Minn., 1960.

Yamamoto, K. Educational achievement of highly creative students: Threshold of intelligence. Research Memorandum BER-61-5. Minneapolis: Bureau of Educational Research, Univer. of Minn., 1961.

Yamamoto, K. Intercorrelations between measures of creative writing and measures of intelligence, reading, language, study-work and arithmetic skills. Research Memorandum BER-62-4. Minneapolis: Bureau of Educational Research, Univer. of Minn., 1962.

APPENDIX A

Titles of Research Projects on Which Summer Science High School Students Produced Independent Reports

Slaughter, Ed. The Effects of Gibberellic Acid on the Growth Rate of Chlorella Pyreniodosa

Cowdrey, Harry. The Effect of the Hapatoma N Tumor on the Folic Acid Content in the Blood and Liver in Male Holtzman Rats

Doerfler, Dennis. The Sodium Chloride (NaCl) Tolerance and Its Signs in Young and Mature Tomato, Asparagus, and Lima Bean Plants

Edelmann, Beth: Susceptibility of Dimorphotheca Aurantiaca to X-Ray Induced Mutations and Modifications at Different Stages of Growth

Tulenko, Timothy. An Investigation of the Growth Rates of Various Gall Tissues in Tissue Culture

Rosenthal, Gail. The Effect of Different Amounts of Vitamin A on the Hepatoma N Tumor in the Male Holtzman Rat

Auchter, Barbara. The Effect of High Caloric Nutrition in Causing Cancer in Small Animals

Fitzgerald, Inez. The Effect of Tap, Filtered, and Well Water on the Growth of Male Holtzman Rats and on the Growth of Hepatoma N Tumor in These Rats

Eitel, Kerry. To Isolate and Identify the Common Respiratory Disease Organisms Affecting Rats and to Determine the Most Satisfactory Method (s) of Curing the Diseases Found in Rats

DePaul, LaDorna. The Effect of Leukemic Long Evans Rat Parents on Their Offspring

Pock, Randolph. The Effect of the Treatment of Otitis Media with Sulfathiazole on Growth of Hepatome N Tumor in Male Holtzman Rats

Scott, Linda. To Isolate and Identify the Common Respiratory Disease Organisms Affecting Rats, and Determine the Most Satisfactory Method of Curing the Diseases

Scruggs, Eugene. Treatment and Isolation of Various Ailments that Infect the Laboratory Rats Used at North Hills High School

Bishop, Margaret. The Cross Breeding of Albino, Blue, and Tan Hood Rats

Carlsen, Cathy. Breeding a Pure Strain of Chinese Hamsters

Wagner, Frank. To Determine if Dissociated Cells from the Same Organs but from Different Organisms Can Reconstitute Themselves to form a Functional Tissue.

Showe, Jon: The Effect of Antibodies to the Hepatoma N Tumor in Male Holtzman Rats

As one illustration of the complexity of some of the studies which were carried on in these programs, one student performed independent research to determine what chemical or groups of chemicals missing from a particular Rat Chow Diet supports Hepatoma N tumor in rats. The research started with the addition of glutamic acid and glycine, the two acids with the largest difference between the diets, to the experimental diet. Tumors injected into rats on this diet grew well. Rats were sacrificed, tumors removed and amino acid were extracted from the tumors and identified by chromatography using filter paper as the matrix with suitable solvents as the carriers .

Questions asked by one student as a result of his independent research on cancer are now being used as a basis of follow-up research for several full time adult researchers.

Other examples of the type and complexity of experimentation carried out by high school students may be found in a report by Riley and Overberger (1961) who describe an excellent summer research participation program for high school students.